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CONTRACT NO. DE-AC05-86OR21548

SAMPLING PLAN FOR THE FEASIBILITY STUDY FOR THE QUARRY RESIDUALS OPERABLE UNIT AT THE WELDON SPRING SITE, WELDON SPRING, MISSOURI

Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

JUNE 1997 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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Environmental Documentation Manager	6/9/97 Date
Data Administration Manager	6/9/97 Date
Project Manager Quarry and Vicinity Properties	09 June 97 Date
Engineering Manager	6-11-97 Date
Project Quality Manager	6-13-97 Date
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Weldon Spring Site Remedial Action Project

Sampling Plan for the Feasibility Study for the Quarry Residuals Operable Unit
at the Weldon Spring Site, Weldon Spring, Missouri

June 1997

Revision 0

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for the

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ABSTRACT

The Quarry Residuals Operable Unit is one of four operable units comprising the Weldon Spring Site Remedial Action Project. The components of this operable unit are: (1) the residual material remaining at the Weldon Spring quarry after removal of the bulk waste; (2) other media located in the surrounding vicinity of the quarry, including adjacent soil, surface water, and sediment in the Femme Osage Slough and several surrounding creeks; and (3) groundwater at the quarry that extends south of the Femme Osage Slough. This sampling plan describes the soil, groundwater, and surface water sampling that will be conducted at the Weldon Spring quarry to provide data to support the Feasibility Study for the Quarry Residuals Operable Unit. The two tasks are (1) determination of distribution coefficients (Kds) in the alluvial materials, and (2) isotopic oxygen (^{18}O and ^{16}O) and isotopic hydrogen (^{2}H and ^{1}H) comparisons for groundwater in the bedrock, alluvium, and Missouri River. This plan will outline the sampling methods, locations, and analysis for each task. Quality control and standard operating procedures will also be discussed.

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1. INTRODUCTION

This plan describes the soil, groundwater, and surface water sampling that will be conducted at the Weldon Spring Quarry to provide data for the evaluation of remedial alternatives for groundwater south of the quarry. The purpose and methodology for this additional data are outlined under this plan.

1.1 Purpose and Scope

The purpose of this plan is to outline the objectives for the two tasks which are needed to support the *Feasibility Study for the Quarry Residuals Operable Unit* (QROU). The two tasks are (1) determination of distribution coefficients (Kds) in the alluvial materials, and (2) isotopic oxygen (^{18}O and ^{16}O) and isotopic hydrogen (^{2}H and ^{1}H) comparisons for groundwater in the bedrock, alluvium, and Missouri River. This plan will outline the sampling methods, locations, and analyses for each task. Quality control and standard operating procedures will also be discussed.

The scope of the first task is to obtain groundwater and soil samples using a vehicle-mounted, hydraulically-powered, soil probing machine, in order to obtain soil and groundwater samples from the same interval at each location. These samples will be used to determine site-specific distribution coefficients for uranium.

The scope of the second task is to sample groundwater utilizing existing monitoring wells and surface water for the determination of a mixing zone in the alluvium south of the quarry. This mixing boundary will be determined by comparing the oxygen isotope ratios (^{18}O: ^{16}O) and hydrogen isotope (^{2}H:^{1}H) ratios at selected bedrock and alluvial wells in the quarry area and the Missouri River.

1.2 Previous Sampling Activities

1.2.1 Distribution Coefficients

Site-specific Kds have not been established for any of the quarry media. A summary of Kds that have been used for the quarry is presented in Table 1-1. Many of these Kds were derived from sorption coefficients calculated using Kds from literature for rock and soil; however, the actual Kds were not presented in the original report (Ref. 1). Kds for the upland soils were estimated from studies performed at the chemical plant on unconsolidated materials in that area (Ref. 2).

Table 1-1 Distribution Coefficients for Uranium

MEDIA	Kd (ml/g)	SORPTION COEFFICIENT	REFERENCE
Fractured Limestone	0.024	1.1	BGA 1984
Alluvium	1.1	3.6	BGA 1984
Clay	6.9	36.4	BGA 1984
Upland Soils	10.7 - 437	---	Schumacher 1993

Sorption coefficients (α) were derived using the following equation (BGA 1984):

$$\alpha = \rho_b/(1-\theta)$$

where: Kd = distribution coefficient
ρ_b = bulk density
θ = effective porosity

1.2.2 ^{18}O: ^{16}O and ^{2}H:^{1}H Ratios

Site-specific oxygen and hydrogen isotope data have not been collected for any of the quarry media.

1.3 Sampling Objectives

The objectives for each sampling task are presented below.

1.3.1 Distribution Coefficients

Groundwater and soil sampling will be conducted to meet the following objectives:

- Determine the uranium concentrations in soils at selected locations and depths.
- Determine the uranium concentrations in groundwater from the same locations and depths as the above soil samples.
- Establish the relationship between the uranium levels in soil and groundwater at each location and depth interval.
- Determine if these relationships correlate to soil types and/or sample locations.

1.3.2 ^{18}O: ^{16}O and ^{2}H:^{1}H Ratios

Groundwater sampling will be conducted to meet the following objectives:

- Determine the ^{18}O, ^{16}O, ^{2}H, and ^{1}H levels in groundwater in the bedrock, alluvium north of the slough, and Missouri River alluvium.
- Determine the ^{18}O, ^{16}O, ^{2}H, and ^{1}H levels in the Missouri River.
- Establish the ratios for ^{18}O and ^{16}O and ^{2}H and ^{1}H for the upland groundwater (bedrock), alluvial groundwater, and the Missouri River.

- Compare the ^{18}O and ^{16}O and $^{2}H:^{1}H$ ratios to determine if they can be used to calculate mixing ratios for the upland groundwater and Missouri River.

2. SAMPLING REQUIREMENTS

This section outlines the sampling method and locations for the two tasks. The volume of sample required and sample preparation for specific analyses are also summarized in this section.

2.1 Distribution Coefficient Determination

2.1.1 Sampling Method

A vehicle-mounted hydraulically-powered soil probing machine will be utilized to obtain soil and groundwater samples at each location. Equipment to be utilized will be *Geoprobe®* or equivalent. Standard operating procedures (SOPs) for the *Geoprobe* ® equipment will be followed. The applicable SOPs are provided in Appendix A.

2.1.1.1 Soils

Samples will be collected from specified depths using a discrete sampler. Liners (clear plastic) will be used to maintain and store samples. The SOP for the *Geoprobe® Large Bore Soil Sampler - Discrete Interval Soil Sampler* (Ref. 3) will be followed during sampling activities.

2.1.1.2 Groundwater

Samples from north of the slough will be obtained by using temporary well points. These well points will be constructed of 1-in. diameter polyvinyl chloride (PVC) (Schedule 40) tubing with a 36-in. screened section pushed by the sampler into the boring used to obtain the soil sample. A steel drive point will be attached to the end and the push rods installed through the PVC for installation. Temporary well points are necessary due to the low hydraulic conductivity of the materials in this area and some development will be necessary to obtain water. Several samplings may be necessary to obtain the necessary sample volume. These well points will be removed prior to 30 days in accordance with 10 CSR 23.

South of the slough, samples will be obtained by using a screen point groundwater sampler. Due to the higher conductivities of the alluvium, temporary well points will not be required. The SOP for either the *Geoprobe® Screen Point Groundwater Sampler* (Ref. 4) or the *Geoprobe® Screen Point 15 Groundwater Sampler* (Ref. 5) will be followed during sampling activities. The water will be obtained adjacent to the location of the soil boring.

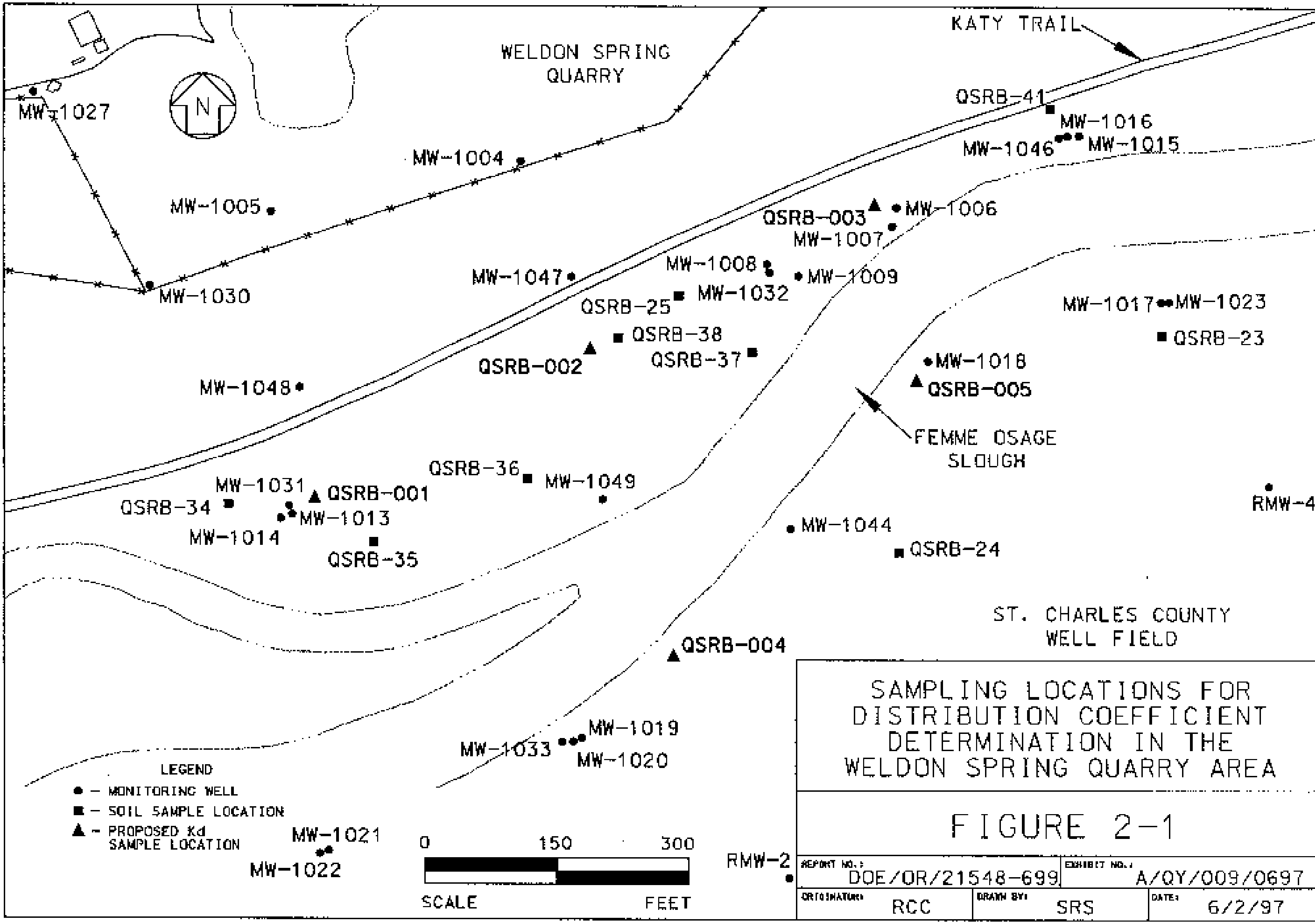
2.1.2 Sample Locations

Soil and groundwater samples will be obtained from five locations north and south of the slough (Figure 2-1). These locations have been selected to represent the width of the uranium plume north of the slough and the potential migration pathways south of the potential migration pathway south of the slough. These locations and the sampling intervals are summarized in Table 2-1. Depths and sampling intervals were determined from previous investigations and current groundwater data.

Table 2-1 Sampling Locations and Intervals for the Determination of Kds

LOCATION	DEPTH TO TOP OF ROCK (ft)	DEPTH TO GROUNDWATER	SAMPLE INTERVAL 1	SAMPLE INTERVAL 2
QRSB-001	20	8	8 - 10	18 20
QRSB-002	15	5	8 - 10	13 - 15
QRSB-003	12	3	3 - 5	10 - 12
QRSB-004	70	15	14 - 16	48 - 50
QRSB-005	50	14	14 - 16	48 - 50

Sample intervals are selected based on lithology in the soil boring, screened interval of nearby wells, uranium concentrations in nearby soil borings, depth to the top of bedrock, and



SAMPLING LOCATIONS FOR DISTRIBUTION COEFFICIENT DETERMINATION IN THE WELDON SPRING QUARRY AREA

FIGURE 2-1

REPORT NO.: DOE/OR/21548-699		EXHIBIT NO.: A/QY/009/0697	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 6/2/97	

depth to groundwater. Sample intervals are selected to meet the following requirements for each boring and should represent:

- Different soil types (i.e., clay, silt, or sand) in each boring.
- The uranium concentrations monitored in nearby wells in at least one sample interval.
- The highest uranium concentrations monitored in a nearby soil boring in at least one sample interval.
- The soil type located directly above the bedrock in the lowest sample interval.
- Saturated conditions.

Soil boring locations are approximate; exact locations will be determined in the field based on accessibility. These locations will be surveyed after sampling activities have been completed.

2.1.3 Sample Preparation

Sample collection and labeling will be performed in accordance with procedures ES&H 4.4.1, *Groundwater Sampling* and ES&H 4.4.5, *Soil/Sediment Sampling*.

Soil and groundwater sample containers, volumes, and preservation requirements are listed in Table 2-2.

Table 2-2 Kd Determination Sampling Requirements

MEDIA	VOLUME	CONTAINER	PRESERVATION
Groundwater	1 liter	plastic	store at 4°C
Soil	100 grams	plastic	store at 4°C

Groundwater samples will be filtered using a 0.45 micron in-line filter to remove sediments and colloids.

Additional groundwater (approximately 100 ml to 200 ml) will be required to obtain field measurements of temperature, pH, and Eh. These measurements will be taken in accordance with the Procedure ES&H 4.4.1, *Groundwater Sampling*.

Soil and groundwater samples will be kept at 4°C immediately after collection and during shipment.

2.2 ^{18}O: ^{16}O and ^{2}H:^{1}H Ratios

2.2.1 Sampling Method

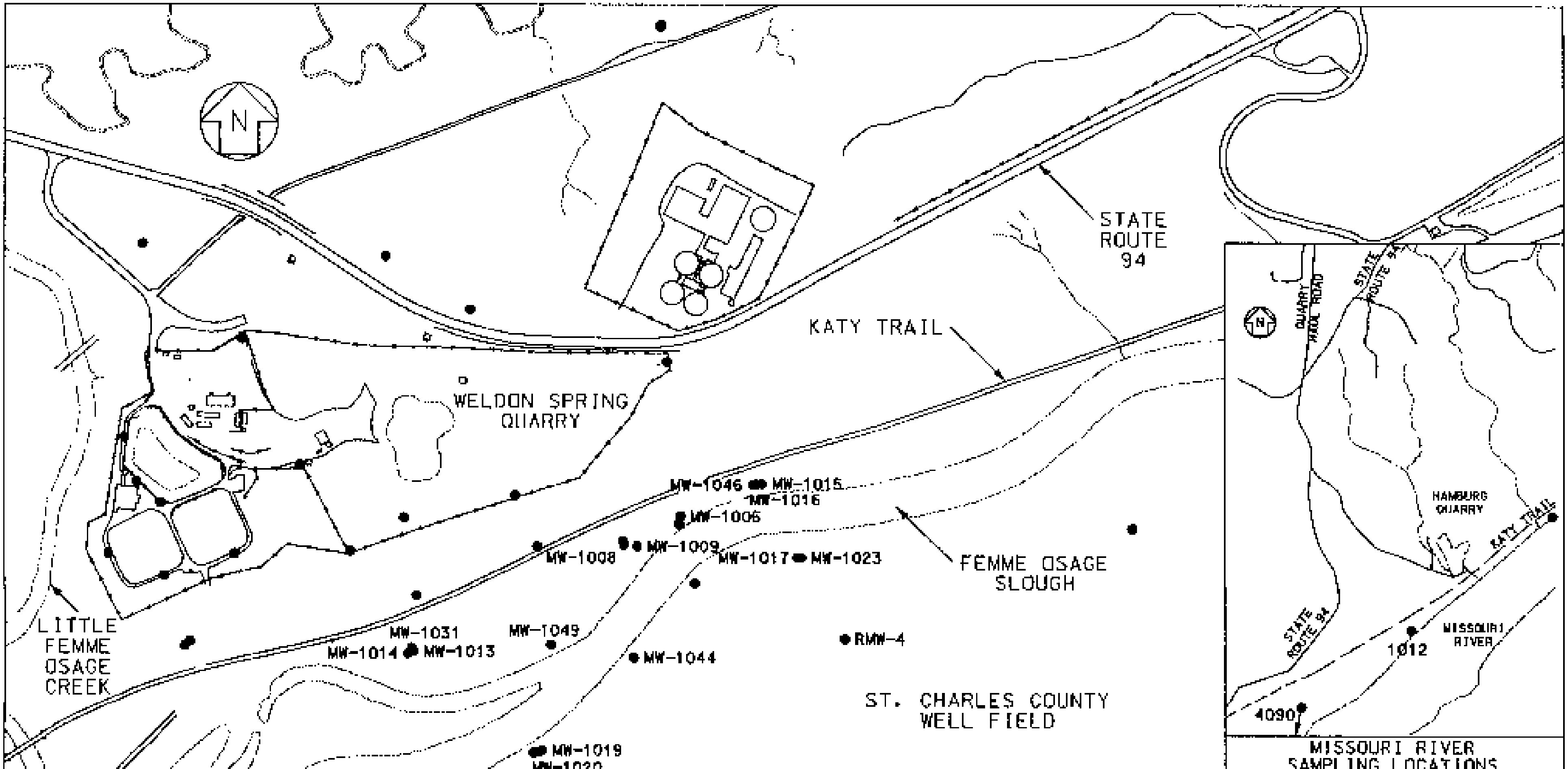
Groundwater samples will be collected in accordance with Procedure ES&H 4.4.1, *Groundwater Sampling*. Surface water samples will be collected in accordance with Procedure ES&H 4.3.1, *Surface Water Sampling*.

2.2.2 Sampling Locations

Samples will be obtained from 19 existing monitoring wells and two locations in the Missouri River (Figure 2-2). Groundwater or surface water sampling are summarized in Table 2-3.

Sampling locations were selected to establish isotopic oxygen and isotopic hydrogen ratios:

- In the bedrock aquifer discharging to the Missouri River Alluvium.
- In the shallow alluvium north of the slough.



LOCATIONS FOR ISOTOPIC OXYGEN AND ISOTOPIC HYDROGEN SAMPLING IN THE WELDON SPRING QUARRY AREA

FIGURE 2-2

REPORT NO.: DOE/OR/21548-699		EXHIBIT NO.: A/QY/010/0697	
ORIGINATOR: RCC	DRAWN BY: SRS	DATE: 6/2/97	

Table 2-3 Oxygen and Hydrogen Isotope Sampling Locations

LOCATION	UNIT	LOCATION	UNIT
GROUNDWATER			
MW-1006	Alluvium (s)	MW-1023	Alluvium (s)
MW-1008	Alluvium (s)	MW-1031	Plattin
MW-1009	Alluvium (s)	MW-1044	Alluvium (s)
MW-1013	Decorah	MW-1046	Plattin
MW-1014	Alluvium (s)	MW-1049	Aluvium (s)
MW 1015	Decorah	MW-RMW2	Alluvium (d)
MW-1016	Alluvium (s)	MW-RMW4	Alluvium (d)
MW-1017	Alluvium (d)	MW-PW08	Alluvium (d)
MW-1019	Alluvium (d)	MW-PW09	Alluvium (d)
MW-1020	Alluvium (s)		
SURFACE WATER			
SW=4090	Missouri River	SW-1012	Missouri River

d Deep alluvium
s Shallow alluvium

- In the Missouri River.

- Across the Missouri River Alluvium.

2.2.3 Sample Preparation

Sample collection and labeling will be performed in accordance with Procedure ES&H 4.4.1, *Groundwater Sampling* and ES&H 4.3.1, *Surface Water Sampling*.

Groundwater sample containers, volumes, and preservations requirements are listed in Table 2-4.

Table 2-4 Oxygen and Hydrogen Isotopic Sample Requirements

MEDIA	VOLUME	CONTAINER	PRESERVATION
Groundwater	40 ml*	plastic	store at 4°C

- Obtain 3 40 ml samples

Groundwater samples will be filtered in accordance with Procedure ES&H 4.5.8, *Water Sample Filtering*. No head space should be left in the sample container by filling to form a negative meniscus.

Field measurements of temperature, pH, and Eh will be taken in accordance with Procedure ES&H 4.4.1, *Groundwater Sampling*.

Samples will be kept at 4°C immediately after collection and during shipment.

3. STANDARD OPERATING PROCEDURES

This section outlines the procedures that will be followed during these sampling events. Some deviations will be made, as noted in the appropriate sections, because the laboratory coordination, data archival and use will be performed by Argonne National Laboratory (ANL), the data requester.

3.1 Sample Identification

Sample numbers will be assigned according to Procedure ES&H 4.1.1, *Numbering System for Environmental Samples and Sample Locations*. A summary of the sample identification number for each location is provided in Table 3-1.

Table 3-1 Sample Identification Numbers

LOCATION	SAMPLE ID	SAMPLE TYPE
QRSB-001	SO-197001-(01,02)	Soil
	IS-197001-(01,0)	Groundwater
QRSB-002	SO-197002-(01,02)	Soil
	IS-197002-(01,02)	Groundwater
QRSB-003	SO-197003-(01,02)	Soil
	IS-197003-(01,02)	Groundwater
QRSB-004	SO-197004-(01,02)	Soil
	IS-197004-(01,02)	Groundwater
QRSB-005	SO-197005-(01,02)	Soil
	IS-1970059(01,02)	Groundwater
MW-1006	GW-1006-(date)	Groundwater
MW-1008	GW-1008-(date)	Groundwater
MW-1009	GW-1009-(date)	Groundwater
MW-1013	GW-1013-(date)	Groundwater
MW-1014	GW-1014-(date)	Groundwater
MW-1015	GW-1015-(date)	Groundwater
MW-1016	GW-1016-(date)	Groundwater
MW-1017	GW-1017-(date)	Groundwater

Table 3-1 Sample Identification Numbers

LOCATION	SAMPLE ID	SAMPLE TYPE
MW-1019	GW-1019-(date)	Groundwater
MW-1020	GW-1020-(date)	Groundwater
MW-1023	GW-1023-(date)	Groundwater
MW-1031	GW-1031-(date)	Groundwater
MW-1044	GW-1044-(date)	Groundwater
MW-1046	GW-1046-(date)	Groundwater
MW-1049	GW-1049-(date)	Groundwater
MW-RMW2	GW-RMW2-(date)	Groundwater
MW-RMW4	GW-RMW8-(date)	Groundwater
MW-PW08	GW-OW04-(date)	Groundwater
MW-PW09	GW-PW09-(date)	Groundwater
SW 1012	SW-1012-(date)	Surface water
SW-4090	SW-4090-(date)	Surface water

3.2 Chain-of-Custody Requirements

Sample chain-of-custody will be maintained in accordance with Procedure ES&H 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain of Custody*. Chain-of-custody forms (COCs) for laboratory samples will be completed and placed in the sample coolers. Sample coolers prepared for shipment will be sealed with chain-of-custody control seals signed and dated by the shipper.

The exception to Procedure ES&H 4.1.2 is that the laboratory coordinator will not generate the COCs or coordinate sample shipment to an off-site laboratory. These tasks will be performed by the sampler. Samples will be shipped to laboratories specified by ANL.

3.3 Sample Shipment

Samples will be packaged and transported to an off-site laboratory, as specified by ANL, in accordance with site procedures. Samples will be shipped per ECDI-3, *HMSTA Operations*. A separate custody record must accompany each sample cooler.

3.4 Equipment Decontamination

All equipment and tools used to collect or transfer samples will be cleaned and decontaminated between each sample. Decontamination will be performed in accordance with Procedure ES&H 4.1.3, *Sampling Equipment Decontamination*. Decontamination wastes will be handled per ECDI-17, *Handling and Disposition of Site-Generated Waste*. Equipment and tools will be stored during sampling activities to maintain cleanliness. This may include use of plastic sheeting, boxes, or other appropriate methods. Where applicable, disposable sampling devices will be employed.

3.5 Borehole Abandonment

Boreholes will be backfilled and abandoned as specified in Procedure ES&H 4.4.4, *Subsurface Monitoring Device Plugging and Abandonment*.

3.6 Documentation

Sample locations, samples collected, and all related data will be recorded in a logbook at the time of collection, as outlined in Procedure ES&H 1.1.4, *Logbook Procedure*.

Field sampling forms generated as a result of this plan will be maintained in accordance with the requirements of Procedure SQP-7, *Quality Assurance Records*.

4. ANALYTICAL METHODS

4.1 Distribution Coefficients

Distribution coefficients (Kds) for uranium will be determined by a method developed at Argonne National Laboratory that is based on a study of complex interactions between dissolved metals and their environment observed in natural systems (Ref. 6). Typically, 20 g to 25 g of soil are contacted with approximately 15 ml to 20 ml of surface water for three weeks at room temperature. For the soil samples located in the aquifer region, filtered groundwater from the soil sample locations will be used. At the end of the contact period, the sample is centrifuged to obtain about 5 ml for the determination of uranium concentration. A separate aliquot of the remaining soil is used for uranium concentration determination in that phase.

4.2 ^{18}O: ^{16}O and ^{2}H:^{1}H Ratios

Oxygen isotopes (^{18}O and ^{16}O) and hydrogen isotopes (^{2}H and ^{1}H) will be determined by Stable Isotope Ratio Analysis (SIRA). The procedure for sample preparation, analytical method, and instrument calibration are provided in Appendix B.

5. QUALITY CONTROL

MK-Ferguson Company, the Project Management Contractor at the Weldon Spring Site Remedial Action Project (WSSRAP) has developed the *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 7) to guide all environmental activities conducted at the WSSRAP in accordance with U.S. Environmental Protection Agency guidelines. The *Sample Management Guide* (Ref. 8) has been developed following the guidelines listed in the EQAPjP. This guide established the approach to sample planning, collection, and data analysis.

Quality control samples will be collected to ensure consistent and accurate performance of sample collection and laboratory analysis. Table 5-1 provides a summary list of the quality control samples that will be collected to support this effort.

Table 5-1 Field Quality Control Sample Summary

QC SAMPLE TYPE	FREQUENCY	PURPOSE
Field Replicate	1 per matrix type (or 1 per 20)	Assess matrix and inter-laboratory variability
Equipment Blank (non-dedicated equipment only)	1 per matrix type (or 1 per 20)	Assess effectiveness of decontamination.

6. REFERENCES

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2. Berkeley Geosciences Associates. *Characterization and Assessment for the Weldon Spring Quarry Low-Level Radioactive Waste Storage Site.* DOE/OR/-853; DE850005424. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. September 1984.

3. Geoprobe® Systems, A Division of Kejr Engineering, Inc. *Geoprobe® Screen Point Groundwater Sampler, Standard Operating Procedure*, Technical Bulletin No. 94-440, Reprinted January 1995.

4. Geoprobe® Systems, A Division of Kejr Engineering, Inc. *Geoprobe®Screen Point 15 Groundwater Sampler, Standard Operating Procedure*, Technical Bulletin No. 95-1500, prepared October 1995.

5. Geoprobe® Systems, A Division of Kejr Engineering, Inc. *Geoprobe® AT–660 Series Large Bore Soil Sampler, Standard Operating Procedure*, Technical Bulletin No. 93-660, revised June 1995.

6. Honeyman, B.D. and Santschi, P.H. *Metals in Aquatic Systems.* Environmental Science and Technology, Volume 22 No. 8 pp 862-871, 1988.

7. MK-Ferguson Company and Jacobs Engineering Group. *Sample Management Guide.* Rev. 0. DOE/OR/21548-499. Prepared for the U. S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. March 1995.

8. MK-Ferguson Company and Jacobs Engineering Group. *Environmental Quality Assurance Project Plan*, Rev. 2. DOE/OR/21548-352. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. May 1996.

PROCEDURES

ECDI-17, *Handling and Disposition of Site-Generated Waste*

ES&H 1.1.4, *Logbook Procedure*

ES&H 4.1.1, *Numbering System for Environmental Samples and Sample Locations*

ES&H 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain of Custody*

ES&H 4.1.3, *Sampling Equipment Decontamination*

ES&H 4.3.1, *Surface Water Sampling*

ES&H 4.4.1, *Groundwater Sampling*

ES&H 4.4.4, *Subsurface Monitoring Device Plugging and Abandonment*

ES&H 4.4.5, *Soil/Sediment Sampling*

SQP-7, *Quality Assurance Records*

CODE OF STATE REGULATIONS

10 CSR 23, *Division of Geology and Land Survey, Well Construction*

APPENDIX A

Geoprobe® Standard Operating Procedures

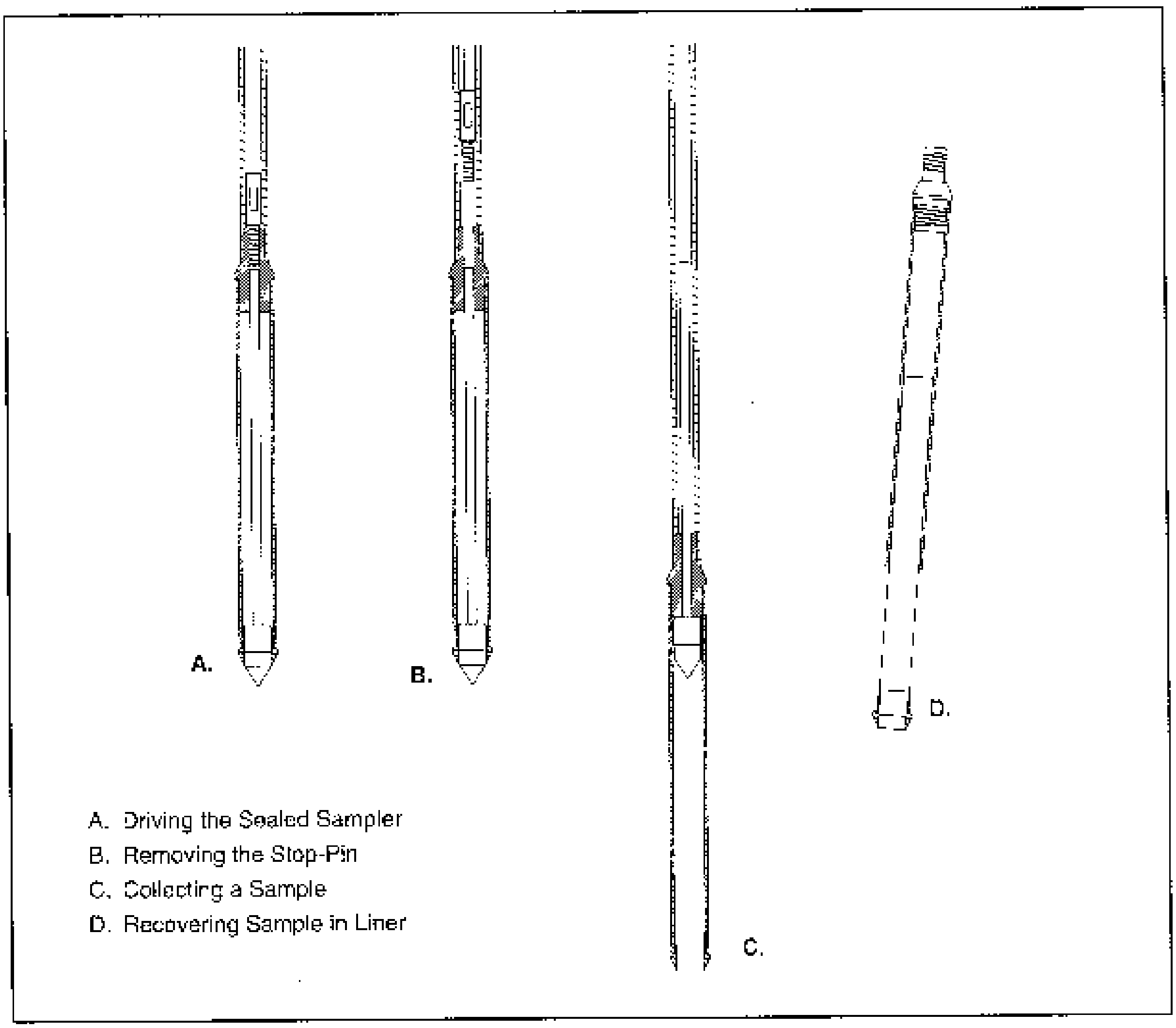
Geoprobe Large Bore Soil Sampler

Discrete Interval Soil Sampler

Standard Operating Procedure

Technical Bulletin No. 93-660

September, 1996



DRIVING AND SAMPLING WITH THE LARGE BORE SOIL SAMPLER

Geoprobe® Systems

Geoprobe® is a Registered Trademark of
Kejr Engineering, Inc., Salina, Kansas

Macro-Core® is a Registered Trademark of
Kejr Engineering, Inc., Salina, Kansas

Large Bore Soil Sampler: U.S. Patent No. 5,186,263

1.0 OBJECTIVE

The objective of this procedure is to collect a discrete soil sample at depth and recover it for visual inspection and/or chemical analysis.

2.0 BACKGROUND

2.1 Definitions

Geoprobe® Soil Probing Machine: A vehicle-mounted, hydraulically-powered machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or groundwater samples.
® Geoprobe® is a registered trademark of Kejr Engineering, Inc., Salina, Kansas

Large Bore Soil Sampler: A 24-inch long x 1-1/2-inch (610 mm x 38 mm) diameter soil sampler capable of recovering a discrete sample that measures up to 320 ml in volume in the form of a 22-inch x 1-1/16-inch (559 mm x 27 mm) core contained inside a removable liner.

Liner: A 24-inch long x 1-1/8-inch diameter (610 mm x 29 mm) removable/replaceable, thin-walled tube inserted inside the Large Bore Sample Tube for the purpose of containing and storing soil samples. Liner materials include brass, stainless steel, Teflon®, and clear plastic (cellulose acetate butyrate).

2.2 Discussion

The Large Bore (LB) Soil Sampler is used primarily as a discrete interval sampler; that is, for the recovery of a sample at a prescribed depth. In certain circumstances, it is also used for continuous coring.

The assembled Large Bore Sampler is connected to the leading end of a Geoprobe brand probe rod and driven into the subsurface using a Geoprobe Soil Probing Machine. Additional probe rods are connected in succession to advance the sampler to depth. The sampler remains sealed (closed) by a piston tip as it is being driven. The piston is held in place by a reverse-threaded stop-pin at the trailing end of the sampler. When the sampler tip has reached the top of the desired sampling interval, a series of extension rods, sufficient to reach depth, are coupled together and lowered down the inside diameter of the probe rods. The extension rods are then rotated clockwise (using a handle). The male threads on the leading end of the extension rods engage the female threads on the top end of the stop-pin, and the pin is removed. After the extension rods and stop-pin have been removed, the tool string is advanced an additional 24 inches. The piston is displaced inside the sampler body by the soil as the sample is cut. To recover the sample, the sampler is retrieved from the hole and the liner containing the soil sample is removed. The operation is illustrated in Figure 1.

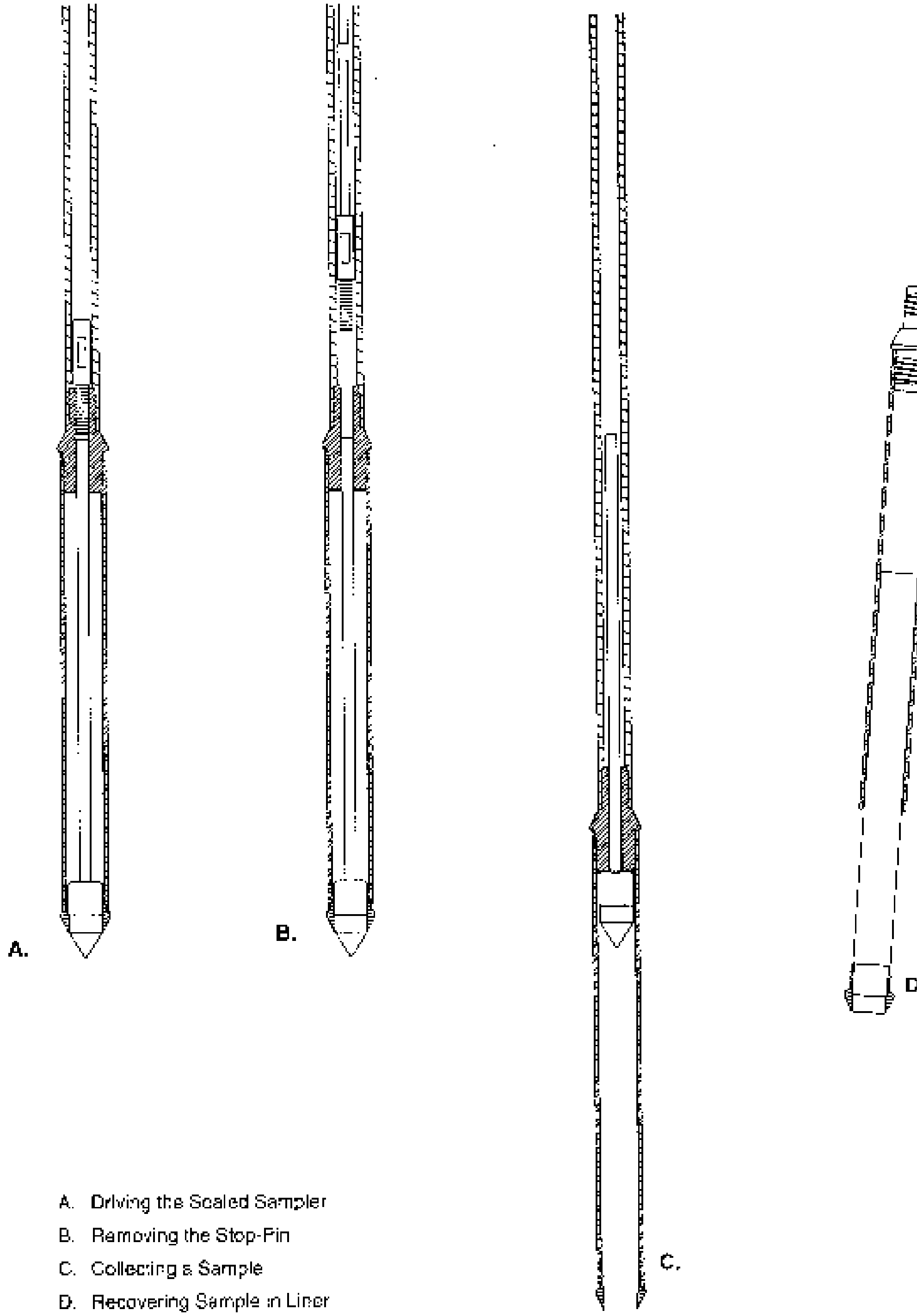


FIGURE 1
Driving and Sampling with the Large Bore Soil Sampler

3.0 REQUIRED EQUIPMENT

The following equipment is required to recover soil cores using the Geoprobe Large Bore Soil Sampler (Fig. 2) and driving systems. Note that the sample liners for the Large Bore Sampler are available in four different materials. Liner materials should be selected based on sampling purpose, analytical parameters, and data quality objectives.

LARGE BORE SAMPLER PARTS	QUANTITY	PART NUMBER
LB Heavy-Duty Cutting Shoe	-1-	AT-6601
LB Heavy-Duty Drive Head, fits 1.25-inch probe rods	-1-	AT-6612
LB Heavy-Duty Sample Tube	-1-	AT-6621
LB Piston Tip	-1-	AT-663
LB Piston Rod	-1-	AT-664
LB Clear CAB Liner	variable	AT-665K
LB Brass Liner	variable	AT-666
LB Stainless Steel Liner	variable	AT-667
LB Teflon® Liner	variable	AT-668
LB Cutting Shoe Wrench	-1-	AT-669
Vinyl End Caps	variable	AT-641K
LB Piston Stop-Pin	-1-	AT-63
LB Piston Stop-Pin O-Ring	variable	AT-63R
Teflon® Tape (optional)	variable	AT-640T
Nylon Brush for LB Tubes	-1-	BU-600

GEOPROBE TOOLS*	QUANTITY	PART NUMBER
Drive Cap, fits 1.25-inch probe rod	-1-	AT-1200
Pull Cap, fits 1.25-inch probe rod	-1-	AT-1204
Probe Rod, 1.25 inch x 12 inches	-1-	AT-1212
Probe Rod, 1.25 inch x 24 inches	-1-	AT-1224
Probe Rod, 1.25 inch x 36 inches (optional)	Variable	AT-1236
Probe Rod, 1.25 inch x 48 inches	Variable	AT-1248
Extension Rod, 36 inch (optional)	Variable	AT-67
Extension Rod, 48 inch	Variable	AT-671
Extension Rod Centering Plug	-2-	AT-6712
Extension Rod Coupler	Variable	AT-68
Extension Rod Handle	-1-	AT-69
Extension Rod Jig	-1-	AT-690
Extension Rod Quick Links (Optional)	Variable	AT-694K
LB Sampler Manual Extruder Kit	-1-	AT-659K

ADDITIONAL TOOLS	QUANTITY	
Locking Pliers	-1-	
Adjustable Open-End Wrench, 1-1/4 inch or	-1-	
MC Combination Wrench	-1-	AT-8590
Open-End Wrench, 3/8 inch	-1-	
Pipe Wrench	-2-	

* Probe rods and accessories are also available in 1-inch O.D. (outside diameter).

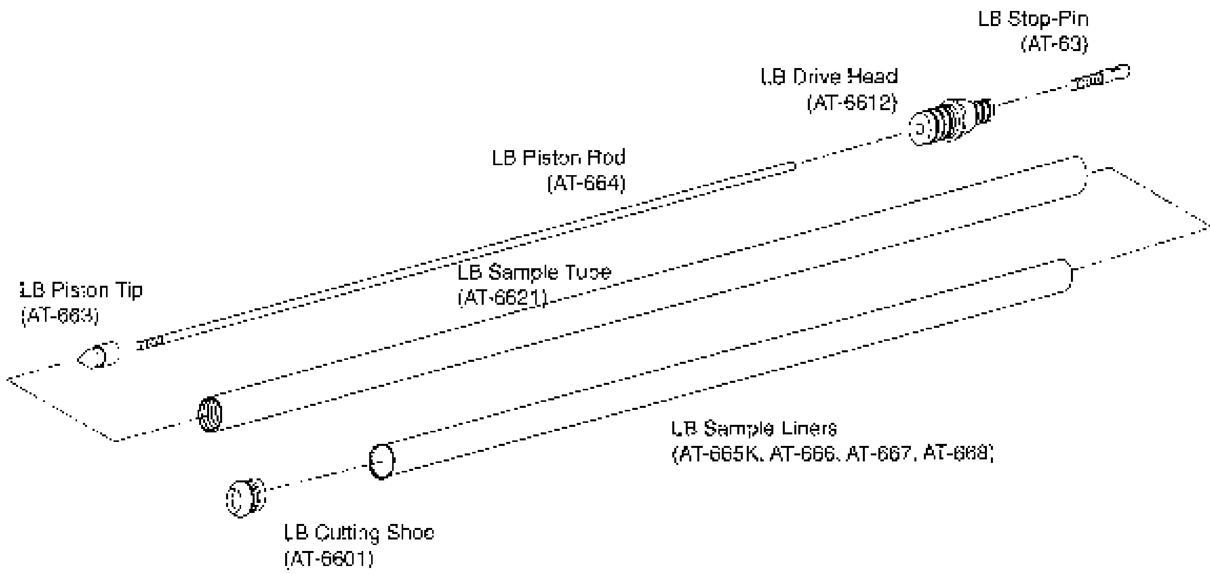


FIGURE 2
Large Bore Soil Sampler Parts

1.0 OPERATION

4.1 Decontamination

Before and after each use, thoroughly clean all parts of the soil sampling system according to specific project requirements. A clean, new liner is recommended for each use. Parts should also be inspected for wear or damage at this time.

4.2 Assembly

1. Install a new AT-63R O-Ring into the O-Ring groove on the stop-pin.

2. Seat the pre-flared end of the LB liner over the interior end of the cutting shoe as shown in Fig. 3. It should fit snugly.

3. Insert the liner into either end of the sample tube and screw the cutting shoe and liner into place. If excessive resistance is encountered during this task, it may be necessary to use the LB shoe wrench. Place the wrench on the ground and position the sampler assembly with the shoe end down so that the recessed notch on the cutting shoe aligns with the pin in the socket of the wrench (Fig. 4). Push down on the sample tube while turning it until the cutting shoe is threaded tightly into place.

4. Screw the piston rod into the piston tip. Insert the piston tip and rod into the sample tube from the end opposite the cutting shoe. Push and rotate the rod until the tip is seated completely into the cutting shoe.

5. Screw the drive head onto the top end of the sample tube, aligning the piston rod through the center bore.

6. Screw the reverse-threaded stop-pin into the top of the drive head and turn it **counterclockwise** with a 3/8-inch wrench until securely tightened (Fig. 5). Hold the drive head in place with a 1-1/4-inch or adjustable wrench while completing this task to assure that the drive head stays completely seated. The Macro-Core® Combination Wrench will also fit the drive head for 1.25-inch probe rods. The assembly is now complete.

4.3 Pilot Hole

A pilot hole is appropriate when the surface to be penetrated contains gravel, asphalt, hard sands, or rubble. Pre-probing will prevent unnecessary wear on the sampling tools. A Large Bore Pre-Probe may be used for this purpose. The pilot hole should be made only to a depth above the sampling interval. Where surface pavements are present, a hole may be drilled with the Geoprobe Soil Probing Machine using a drill steel (AT-3524, AT-3536, or AT-3548 depending upon the thickness of the pavement), tipped with a 1.5-inch diameter carbide drill bit (AT-36) prior to probing.

NOTE: Some soil conditions may warrant using a solid drive point (AT-142B) to pre-probe the hole to the desired sampling depth. Information about the subsurface and depth to bedrock should be known before driving the sampler. Damage may occur if the sampler is driven into rock or other impenetrable material.

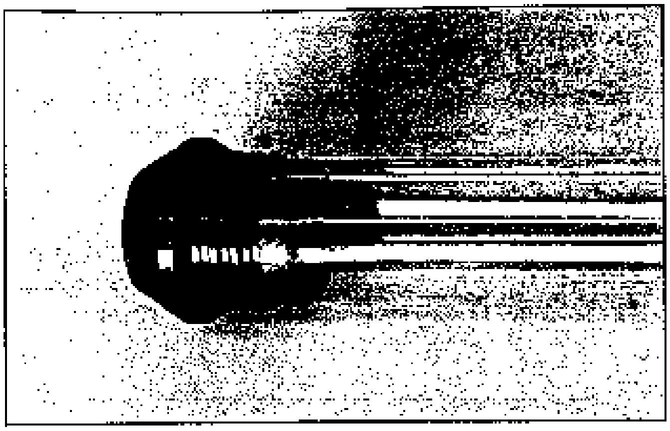


Figure 3. Liner fits snugly over interior end of cutting shoe.

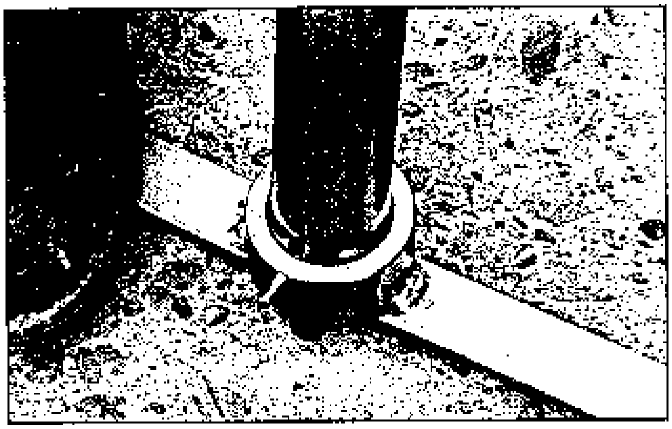


Figure 4. Using the AT-669 Cutting Shoe Wrench to attach cutting shoe.

Figure 5. Tightening the Stop-pin.

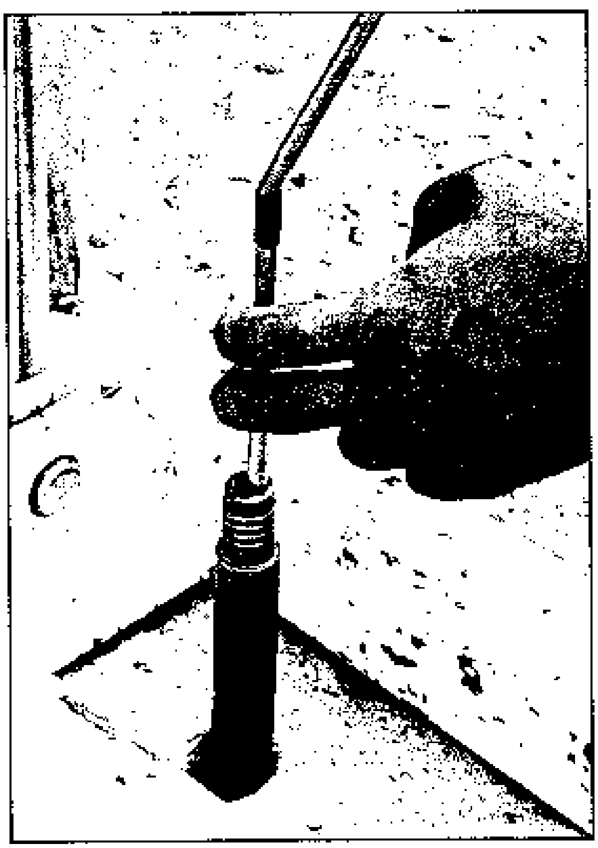


Figure 7. Coupling Extension Rods together.

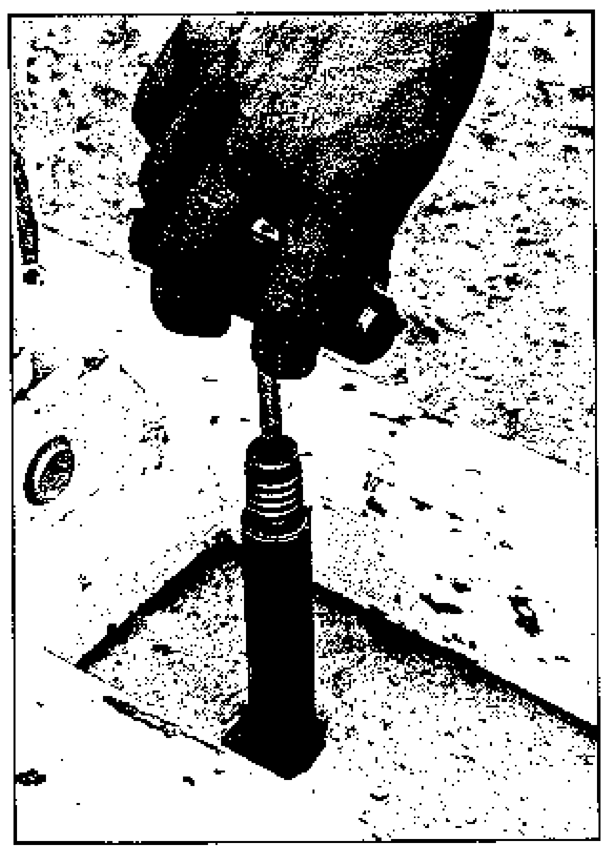


Figure 8. Rotating the Extension Rod Handle.

4.4 Driving

1. Attach a drive cap to a one-foot probe rod and thread the rod onto the assembled sampler. Position the assembly for driving into the subsurface.

2. Drive the assembly into the subsurface until the drive head on the sample tube is just above the ground surface.

3. Remove the drive cap and one-foot probe rod. Secure the drive head with a 1-1/4-inch open-end, adjustable wrench or a Macro-Core® combination wrench, and re-tighten the stop-pin with a 3/8-inch open-end wrench (Fig. 5).

4. Attach the drive cap to a two-foot probe rod and continue driving the sampler into the ground. Attach three- or four-foot probe rods in succession until the leading end of the sampler reaches the top of the desired sampling interval.

4.5 Preparing to Sample

1. When sampling depth has been reached, position the Geoprobe machine away from the top of the probe rod to allow room to work.

2. Insert an extension rod down the inside diameter of the probe rods. Hold onto it and place an extension rod coupler or Quick Link extension rod connectors (Fig. 6) on the top threads of the extension rod (the downhole end of the leading extension rod should remain uncovered). Attach another extension rod to the coupler and lower the jointed rods down hole (Fig. 7). An extension rod jig (Fig. 6) may be used to help hold the rods during Steps 2 and 3.

3. Couple additional extension rods together in the same fashion as in Step 2. The leading extension rod must reach the stop-pin at the top of the sampler assembly. When coupling extension rods together, you may opt to use the extension rod jig to hold the downhole extension rods while adding additional rods.

4. When the leading extension rod has reached the stop-pin down hole, attach the extension rod handle to the top extension rod.

5. Turn the handle **clockwise** until the stop-pin detaches from the threads on the drive head (Fig. 8). Pull up lightly on the extension rods during this procedure to check thread engagement.

   NOTE: The larger inside diamter (I.D.) of the 1-1/4-inch probe rods can make it difficult to engage the stop-pin. To remedy this problem, attach an Extension Rod Center Plug to the bottom of the first extension rod. Another centering plug may be necessary between the first and second extension rods if the extension rods are slightly bent.

6. Remove the extension rods and uncouple the sections as each joint is pulled from the hole. The extension rod jig may be used to hold the rod couplers in place as the top extension rods are removed.

7. The stop-pin should be attached to the bottom of the last extension rod upon removal. Inspect it for damage. Once the stop-pin has been removed, the sampler is ready to be driven to collect a sample.

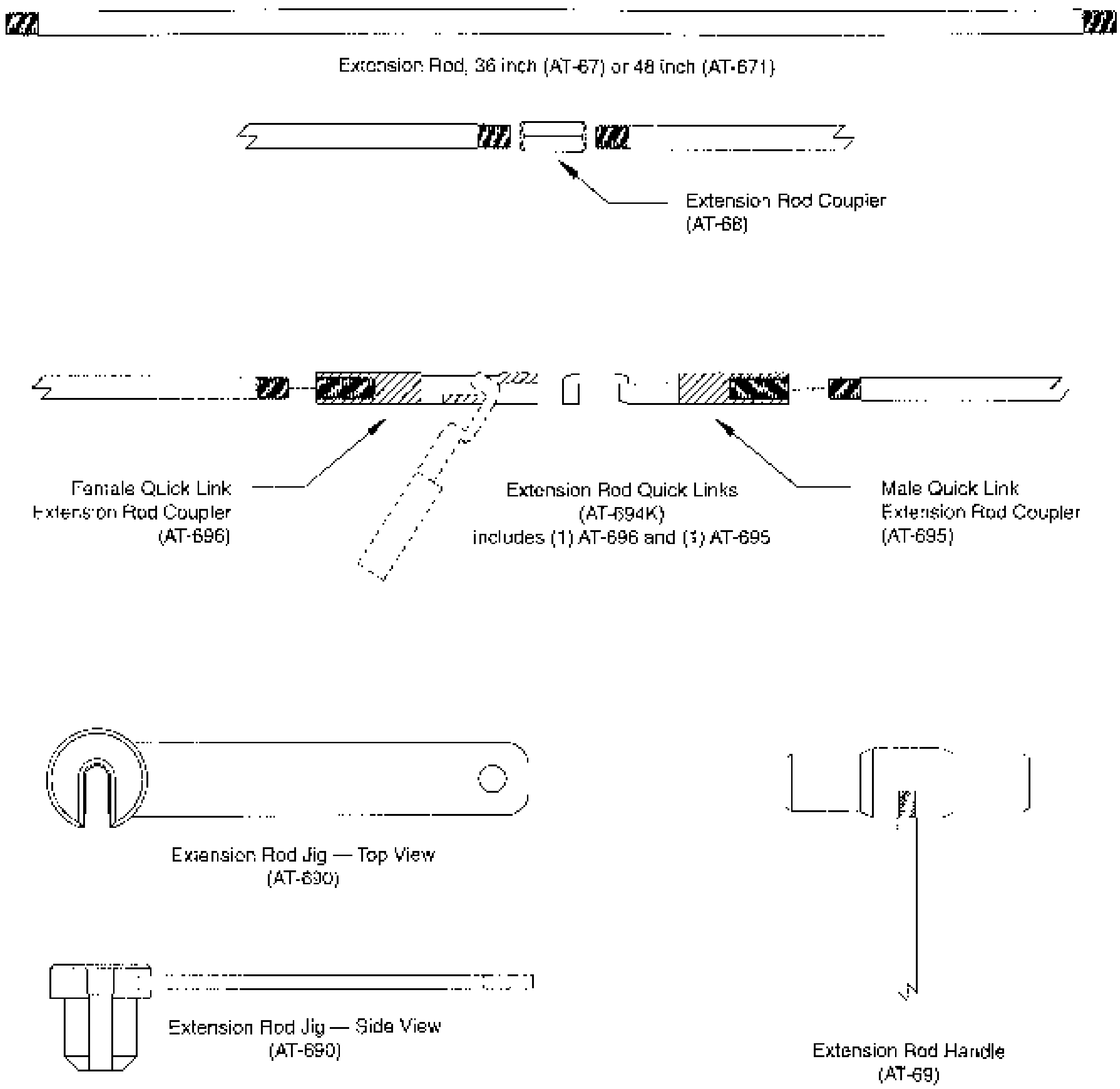


FIGURE 6
Geoprobe Extension Rods and Accessories

4.6 Sample Collection

1. Reposition the Geoprobe machine over the probe rods, adding an additional probe rod to the tool string if necessary. Make a mark on the probe rod 24 inches above the ground surface (this is the distance the tool string will be advanced).

2. Attach a drive cap to the probe rod and drive the tool string and sampler another 24 inches. Acutate the hammer function during sample collection to increase sample recovery. Do not over-drive the sampler.

4.7 Retrieval

1. Remove the drive cap from the top probe rod and attach a pull cap. Lower the hammer assembly and close the hammer latch over the pull cap.

2. With the machine foot firmly on the ground, pull the tool string out of the hole. Stop when the top (drive head) of the sampler is about 12 inches above the ground surface.

3. Because the piston tip and rod have been displaced inside the sample tube, the piston rod now extends into the two-foot probe rod section. In loose soils, the two-foot probe rod and sampler may be recovered as one piece by using the Foot Control on the probe machine to lift the sampler the remaining distance out of the hole.

4. If excessive resistance is encountered while attempting to lift the sampler and probe rod out of the hole using the Foot Control, unscrew the drive head from the sampler and remove it with the probe rod, the piston rod, and the piston tip. Replace the drive head onto the sampler and attach a pull cap to it. Lower the hammer assembly and close the hammer latch over the pull cap and pull the sampler the remaining distance out of the hole with the probe machine foot firmly on the ground.

4.8 Sample Recovery

1. Detach the two-foot probe rod if it has not been done previously.

2. Unscrew the cutting shoe using the LB Cutting Shoe Wrench, if necessary. Pull the cutting shoe out with the liner attached (Fig. 9). If the liner doesn't slide out readily with the cutting shoe, take off the drive head and push down on the side wall of the liner. The liner and sample should slide out easily.

4.9 Core Liner Capping

1. The ends of the liners can be capped off using the vinyl end caps for further storage or transportation. A black end cap should be used at the bottom (down end) of the sample core and a red end cap at the top (up end) of the core.

2. On brass, stainless steel, and Teflon® liners, cover the end of the sample tube with AT-640T Teflon® tape before placing the end caps on the liner (Fig. 10). The tape should be smoothed out and pressed over the end of the soil core so as to minimize headspace. However, care should be taken not to stretch and therefore thin the Teflon® tape.

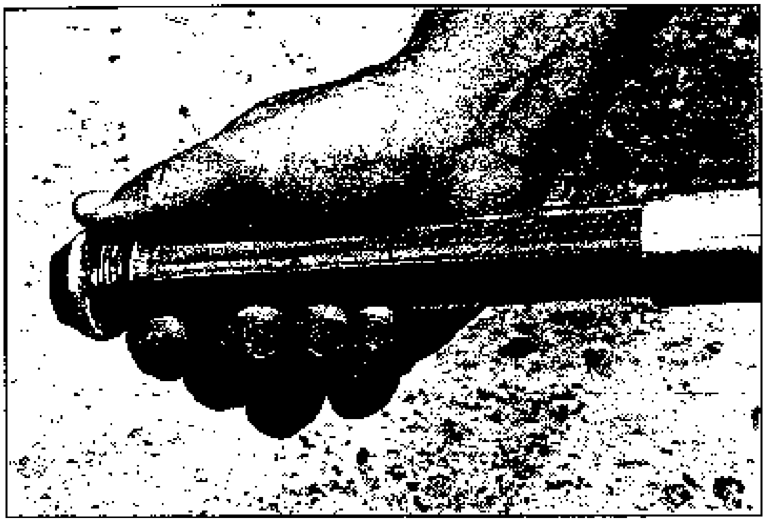


Figure 9. Removing the liner to recover the Sample.

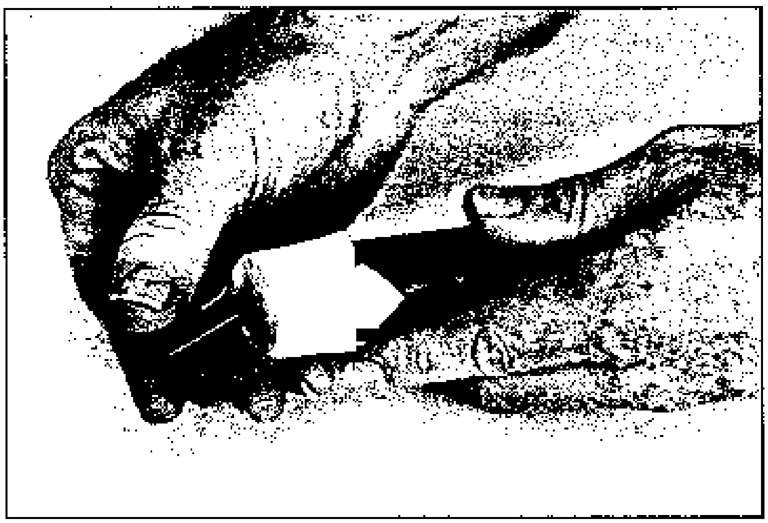


Figure 10. Covering the liner end with Teflon tape for capping.

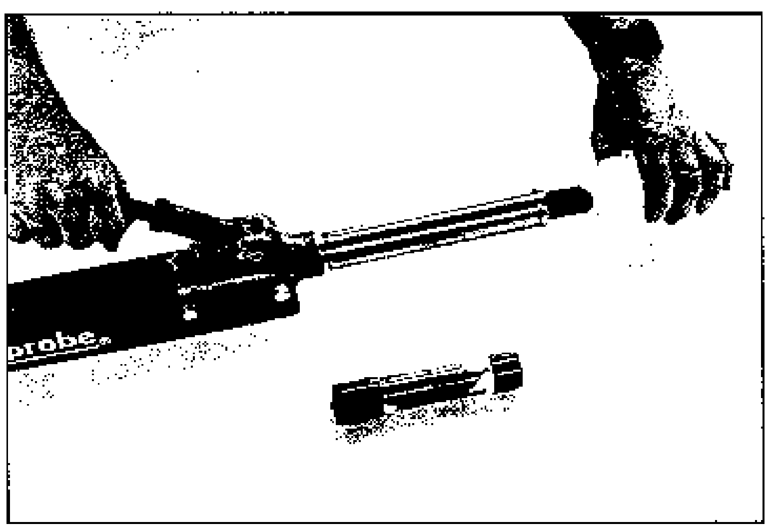


Figure 11. Extruding a sample in a metal liner using the AT-659K manual extruder.

4.10 Sample Removal

1. Large Bore clear plastic liners and Teflon® liners can be slit open easily with a hooked-blade utility knife for the samples to be analyzed or placed in appropriate containers.

2. Large Bore brass and stainless steel liners come with plastic cladding on the outside of the liner to keep four 6-inch sections aligned. Remove the cladding and cut the sections apart with a knife. The Large Bore Manual Extruder may be used to push the soil cores out of the liner sections for analysis or for transfer to other containers (Fig. 11).

CAUTION: Use extreme care when using the Large Bore Manual Extruder. Gradually apply down pressure on slow speed. Use of excessive force could result in injury to the operator or damage of the tools.

6.0 REFERENCES

Geoprobe Systems, August, 1993, "1993-94 Tools and Equipment Catalog".

Geoprobe Systems, May, 1995, "1995-96 Tools and Equipment Catalog".

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems.

GEOPROBE SCREEN POINT GROUND WATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. 94-440

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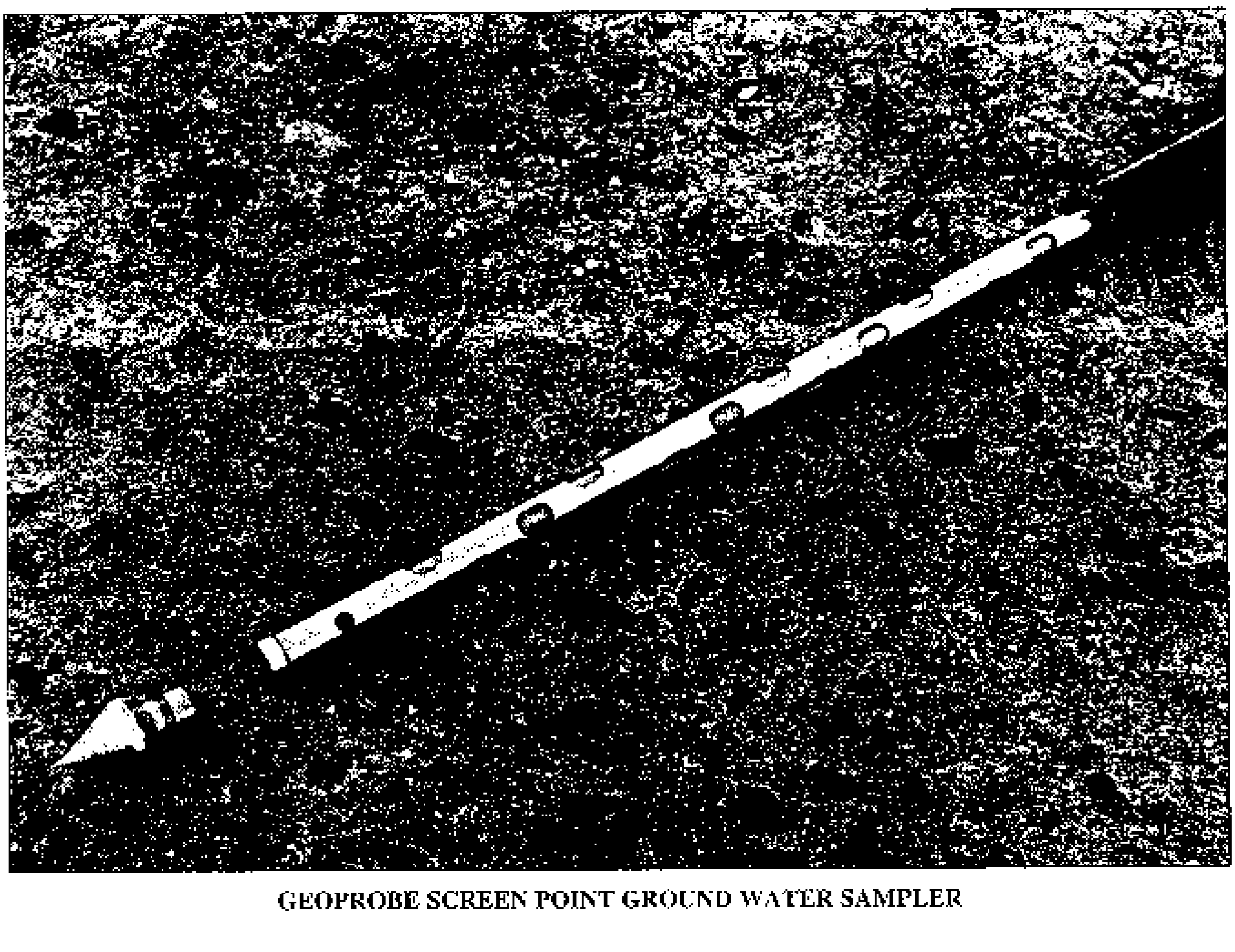
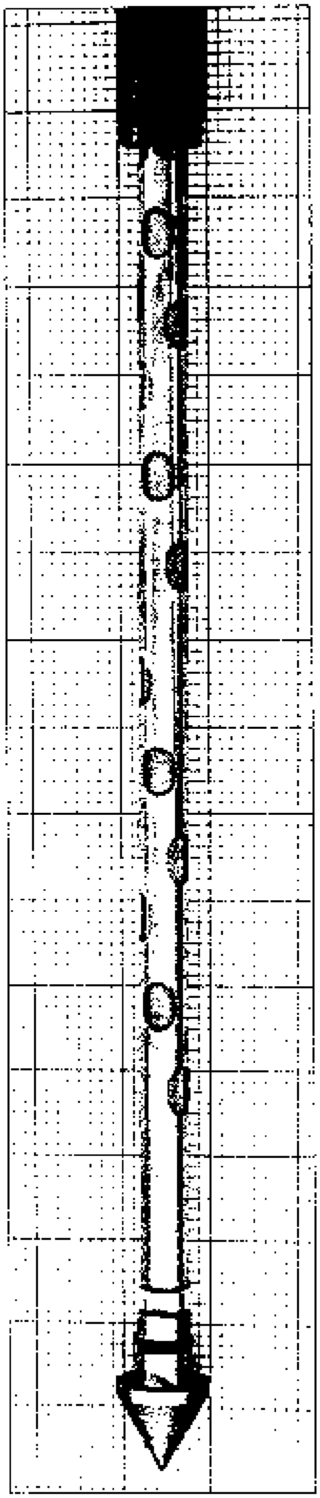


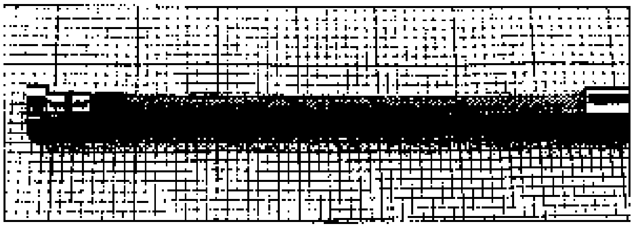
GEOPROBE SCREEN POINT GROUND WATER SAMPLER

Geoprobe® Systems

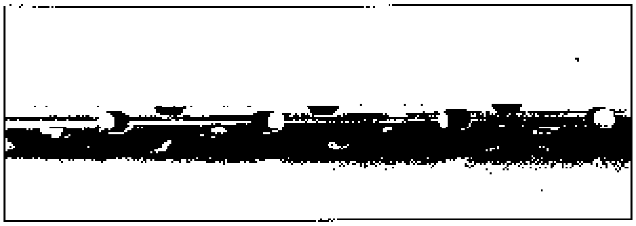
A DIVISION OF KEJR ENGINEERING, INC.



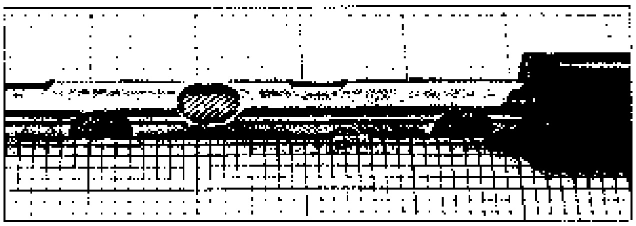
Ground Water
Screen Point Sampler



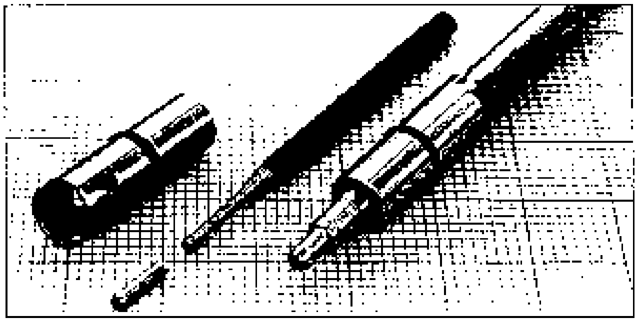
Screen insert (P/N GW-444) with plug and O-ring.



Screen sleeve (P/N GW-441).



Screen point sampler in open position.



Bottom end of screen connector showing O-ring and connector pin location (left). Top end of screen connector (P/N GW-443) showing PRT adapter and fitting (right). Pin punch (P/N GW-447) (center).

1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel screen to depth, open the screen, and obtain a water sample via a tubing system to the surface.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A vehicle-mounted hydraulically-powered soil probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or ground water samples.
(®Geoprobe is a registered trademark of Kejr Engineering, Inc., Salina, Kansas.)

Screen Point Ground Water Sampler: The assembled Screen Point Sampler (P/N GW-440K) is 1.0-inch O.D. (outside diameter) x 36-inch overall length. This sampler features a 19-inch screen encased in a perforated stainless steel sleeve. The device is also useful for measurement of piezometric levels.

2.2 Discussion

In this procedure, the assembled Screen Point Sampler threads onto the leading end of a Geoprobe probe rod and is driven into the subsurface using a Geoprobe machine. Additional probe rods are connected in succession to advance the sampler to depth. While the Screen Point Sampler is being driven to the desired sampling depth, it is kept sealed by O-ring connections placed at critical locations on the assembly.

When the desired sampling depth is reached, the sampler is pulled up about 2 feet which disengages the expendable drive point and creates an open borehole from which to sample. The inner core, which consists of a stainless steel wire screen inside of a perforated stainless steel sleeve, is then pushed out into the borehole and water is allowed to enter the sampler and connected probe rods.

In common practice, ground water samples are recovered by pumping or bailing of water collected in the open probe rods. Alternately, tubing from the surface may be connected directly to the sampler screen using a Geoprobe PR (post run) fitting, and samples recovered using a peristaltic pump or vacuum source. The pore size of the screen of this sampler is .0057 inches (0.145 mm). This sampler will allow the user to collect relatively clean water samples in a short time period due to its large surface area.

3.0 REQUIRED EQUIPMENT

Equipment required to successfully recover water samples using the Geoprobe Screen Point Ground Water Sampler is listed below. These parts are shown in Fig. 3.2 and are shown in their assembled condition in Fig. 3.1.

SCREEN POINT GROUND WATER SAMPLER PARTS	QUANTITY	GEOPROBE PART NUMBER
Ground Water Sampler Drive Head	1	GW-430B
O-Ring for GW Sampler Drive Head	25	GW-430R
Screen Point Sampler Sheath	1	GW-440
Drive Point Seat	1	GW-440-1
O-Ring for Drive Point Seat	25	GW-440-1R
Screen Sleeve	1	GW-441
Screen Connector w/ PRT-Adapter Threads	1	GW-443
O-Ring for Screen Connector	25	GW-443R
Screen Insert and Plug (assembled)	2	GW-444
O-Ring for Screen Plug	25	GW-444R
Expendable Drive Point	25	GW-445
O-Ring for Drive Point	25	GW-445R
Screen Connector Pin	1	GW-446
Screen Connector Pin Punch	1	GW-447

GEOPROBE TOOLS	QUANTITY	GEOPROBE PART NUMBER
Probe Rod (4 foot)	variable	AT-104B
or		
Probe Rod (3 foot)	variable	AT-10B
Probe Rod (2 foot)	1	AT-105B
Probe Rod (1 foot)	1	AT-106B
Drive Cap	1	AT-11B
Pull Cap	1	AT-12B
Extension Rod	variable	AT-67
Extension Rod Coupler	variable	AT-68
Extension Rod Handle	1	AT-69

OPTIONAL	QUANTITY	PART NUMBER
Tubing Bottom Check Valve	2	GW-42
Check Balls for Check Valve	25	GW-42-1
Polyethylene Tubing, 1/4-inch I.D.	variable	TB-25L
Probe Rod Pull Plate	1	AT-122
PRT Fitting	1	PR-25S
or		
PRT Fitting	1	PR-30S

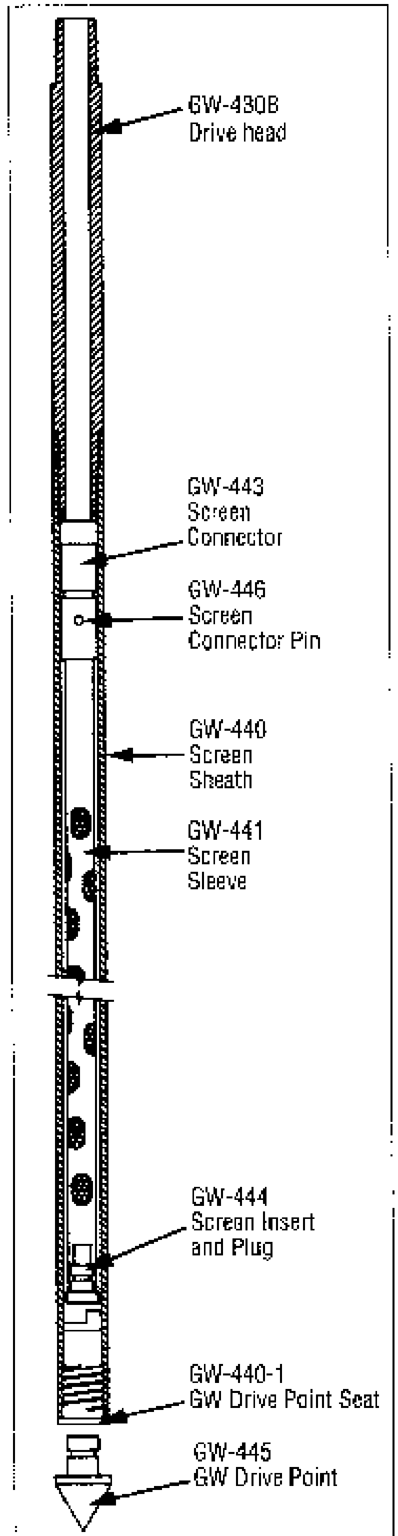


Figure 3.1. Cross-Sectional View of assembled Ground Water Screen Point Sampler

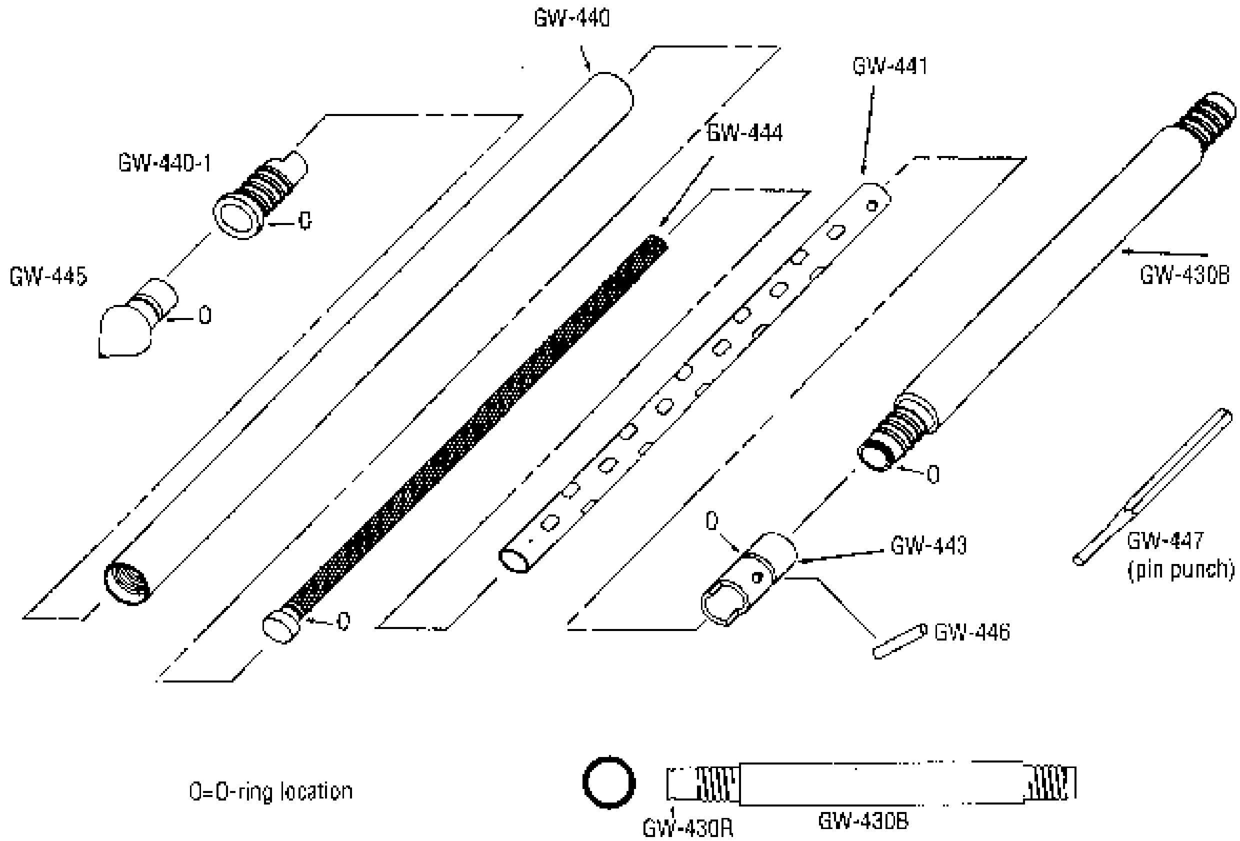


FIGURE 3.2

Screen Point Ground Water Sampler Parts
GW-440 Series

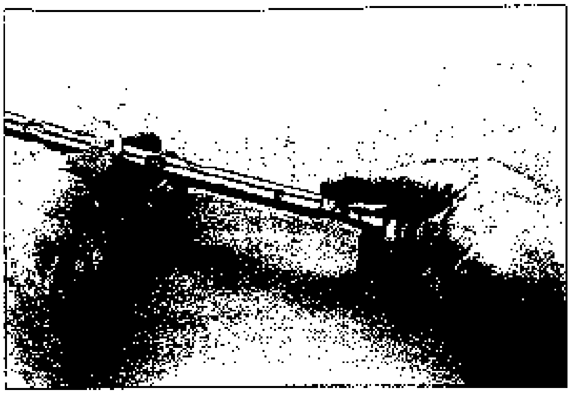


Figure 4.1. Pushing the Screen Insert and Plug into the Screen Sleeve.

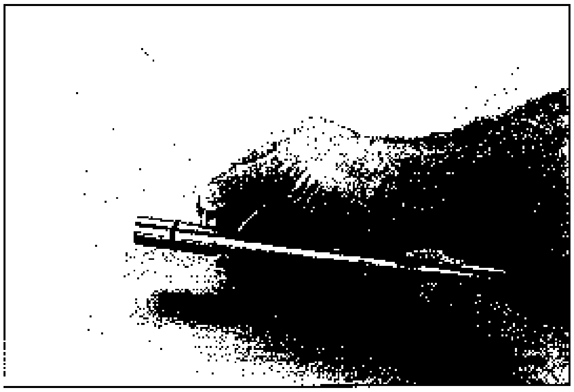


Figure 4.2. Pushing the Screen Connector Pin into place.

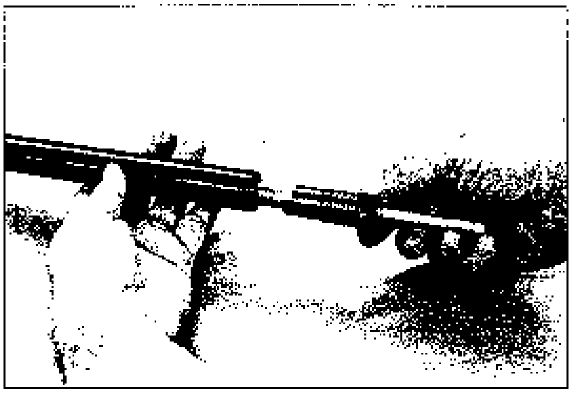


Figure 4.3. Installing Drive Point Seat.

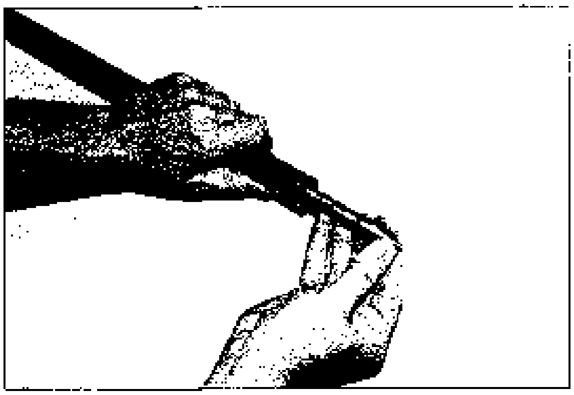


Figure 4.4. Expendable Drive Point next to Sampler Sheath in bottom end of Drive Point Seat.

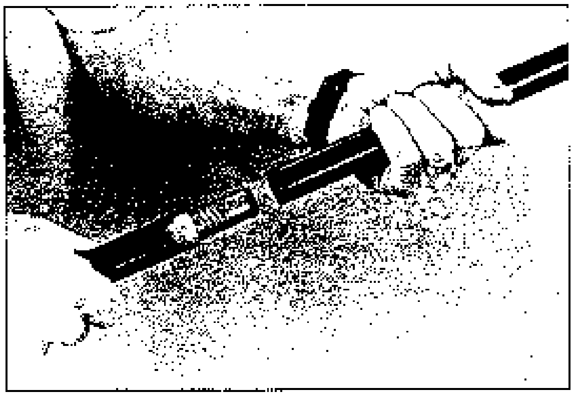


Figure 4.5. Screwing Water Sampler Drive Head into top of Sampler Sheath.

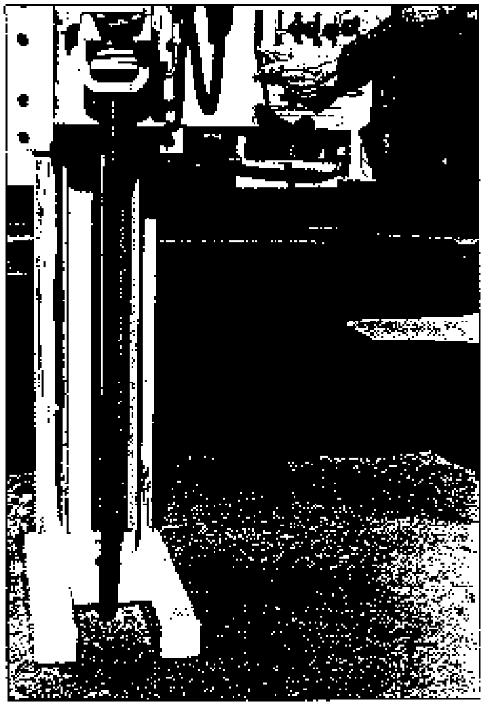


Figure 4.6. Driving the Screen Point Sampler.

4.0 OPERATION

4.1 Basic Operation

The outer appearance of the Screen Point Ground Water Sampler, once it has been assembled properly, looks just like a normal Geoprobe 3-foot probe rod. The bottom is fitted with an expendable drive point, while the top part of the sampler can simply be connected to Geoprobe rods and other accessories. The assembled sampler can be driven either hydraulically by any Geoprobe Model machine or manually by using drilling machines, or by using cone penetrometers.

At sampling depth, the probe rods attached to the sampler are retracted two feet to allow the sampler screen to be pushed out into the formation.

4.2 Decontamination and Preparation of Parts

In order to assemble the water sampler properly and to take accurate and precise water samples, all parts need to be cleaned thoroughly and, if necessary, individually decontaminated prior to their use. For each test run, fresh, decontaminated sampler parts and O-rings should be used.

All parts should be washed with soapy water. All soil adhering to the parts should be removed by brushing or pressure washing. Finally, all parts should be rinsed with clean, contaminant-free water and allowed to dry before they are assembled.

Check all five O-rings in the sampler assembly for damage and/or wear. For reliable tests, we recommend the use of new O-rings on this tool at each sampling. It is more efficient and cost effective to change O-rings rather than collecting a non-representative sample or invalid data.

4.3 Assembly

Figure 3.2 presents a diagram of the unassembled screen point sampler parts. Assembly instructions are as follows.

a. Push the screen insert and plug (P/N GW-444), equipped with an O-ring (P/N GW-444R), into the screen sleeve (P/N GW-441), which is the end of the screen sleeve with only one drain hole. This operation is shown in Figure 4.1

b. Push the screen connector (P/N GW-443), which is fitted with an O-ring (P/N GW-443R) over the top of the screen sleeve and secure with the connector pin (Figure 4.2). The pin can easily fall out since it is a rather loose fit.

c. Insert the screen connector end of the assembled screen sleeve halfway into the screen point sampler sheath (P/N GW-440) from either end. Again, the screen connector end is inserted first.

d. Slide the drive point seat (O-ring P/N GW-440-1R) over the outstanding end of the screen sleeve and screw it tightly into the sampler sheath (Figure 4.3).

e. Push the screen sleeve up into the sampler sheath just far enough to fit the expendable drive point (O-ring GW-445R) into the bottom end of the drive point seat (Figure 4.4).

f. Screw the O-ring end of the water sampler drive head (P/N GW-430B) into the top of the sampler sheath (Fig. 4.5). Make sure all threads are fastened tightly.

4.4 Probing

a. Drive the water sampler approximately two-foot below the depth level where you want to sample by simply attaching it to Geoprobe rods (Fig. 4.6).

b. Never drive the water sampler without the O-ring (P/N GW-445R) attached to the drive point. Failure to use this O-ring may result in flowing soils clogging the screen during driving.

4.5 Screen Deployment

Once the Screen Point Ground Water Sampler has been driven to the base of the interval desired for sampling, the probe rods are retracted a distance of 2 feet (607 mm) and the screen is pushed out into the formation. The following procedures are employed to deploy the screen:

a. Retract the probe rods from the ground a distance of 24 inches (607 mm) as shown in Figure 4.7.

b. Insert Geoprobe stainless steel extension rods (P/N AT-67), as shown in Fig. 4.8, down the bore of the probe rods (Fig. 4.9). An extension rod coupler (P/N AT-68) must be placed at the bottom end of the lead extension rod in order to protect the threads at the end of this rod (Fig. 4.10). One extension rod will be required for each probe rod in the ground, plus one extension rod for the screen point sampler itself. Place an extension rod handle (P/N AT-69) at the top of the extension rod string.

c. When the proper number of extension rods have been coupled together and inserted down the bore of the probe rods, the last extension rod will protrude from the top of the probe rods a distance of approximately 24 inches (607 mm).

d. Pushing down on the extension rods should now push the screen out into the formation. When the screen is completely pushed out, the extension rod handle will come to rest at a final position approximately 3 inches (76 mm) above the top of the probe rods.

e. In extreme situations, it may be necessary to tap on the top of the extension rod handle with a hammer in order to force the screen out into the formation.

4.6 Sampling, General Considerations

There are two methods for obtaining a sample from the GW-440 series Screen Point Sampler. Ground water samples can be obtained by bailing or pumping directly from the bore of the probe rods above the screen point. Alternately, a tubing system may be attached directly to the top of the deployed screen and samples pumped to the surface using either a peristaltic pump or other means of vacuum lift. These two techniques are illustrated in Figure 4.11.

4.7 Bottom Check Valve Sampling

The most common methods employed is to pump directly from the bore of the probe rods immediately above the screen point using a tubing bottom check valve. This method is often referred to as sampling from the open rods, and is essentially the same for bottom check valve sampling as it is for bailing. Note that in order for this method to be employed, the piezometric head in the saturated formation must be above the top of the deployed screen point; water from the formation must rise into the probe rods where it can then be pumped to the surface. Sampling is performed as described in the following steps.

a. Either 3/8 inch (9.5 mm) O.D. Teflon (P/N TB-30T) or Polyethylene (P/N TB-25L) tubing may be used for ground water sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the groundwater investigation.

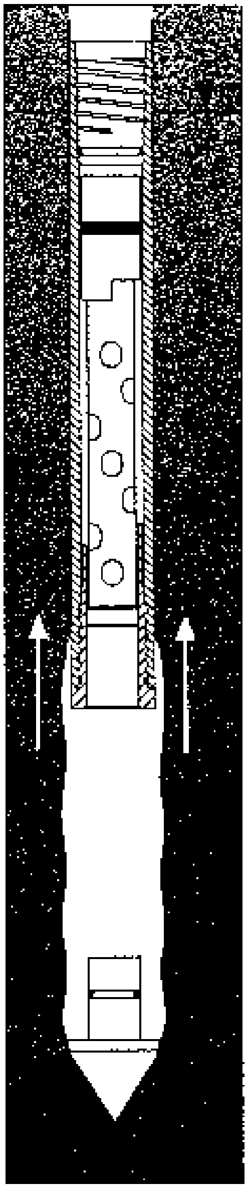


Figure 4.7. Retract Probe Rods two feet (60 cm) prior to releasing screen out into the formation.

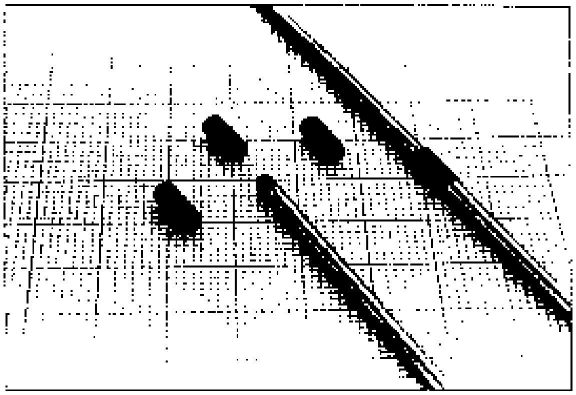


Figure 4.8. Extension Rods and Couplers.

Figure 4.9. Joining Extension Rods together with Couplers.

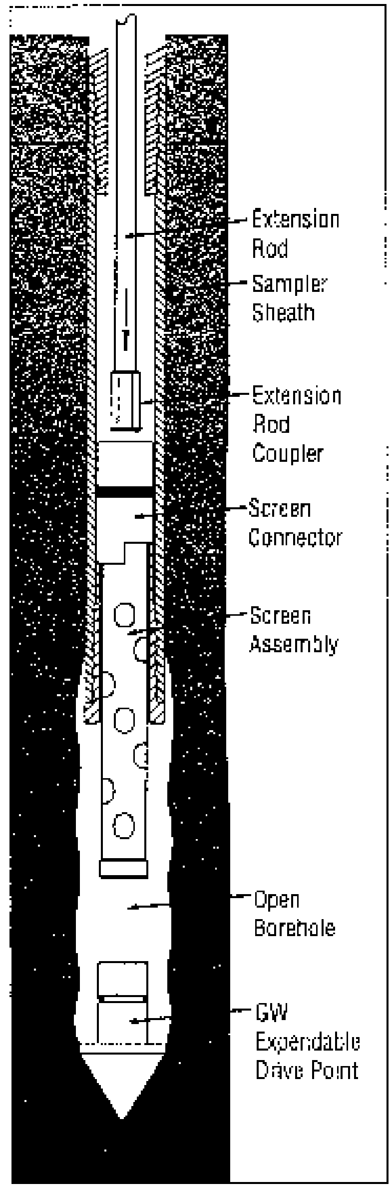


Figure 4.10. Pushing out Screen Assembly with Extension Rods.

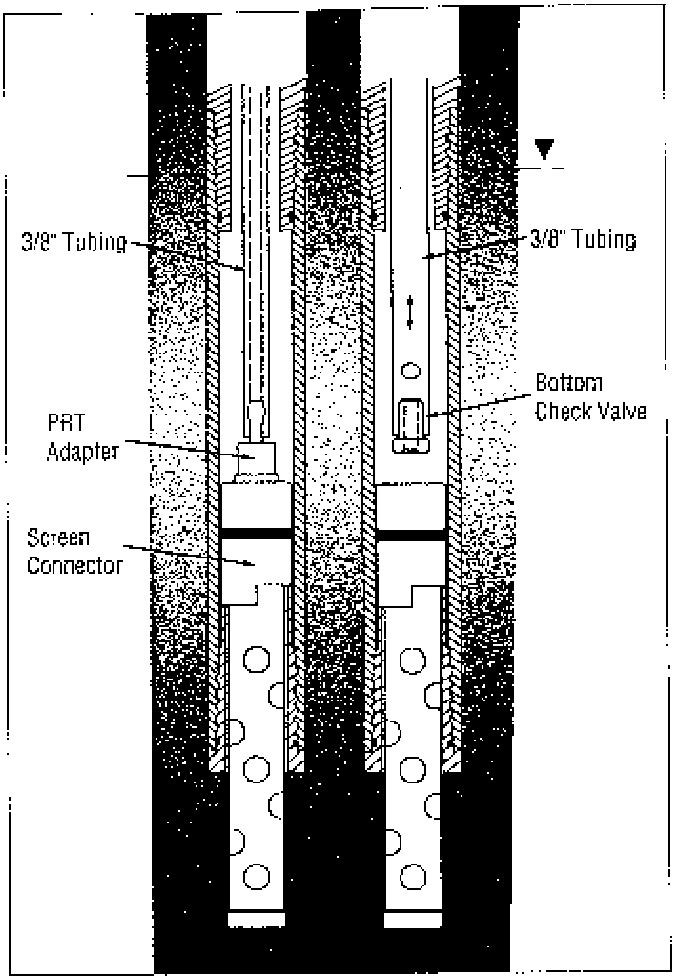


Figure 4.11. Sampling options. Direct PRT attachment (left) and check valve pump technique (right).

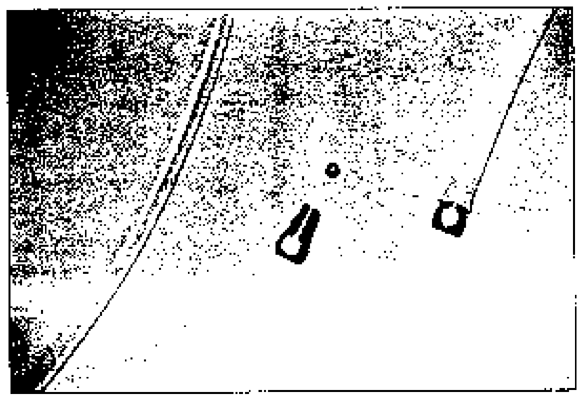


Figure 4.12. Tubing Bottom Check Valve and Polyethylene Tubing.

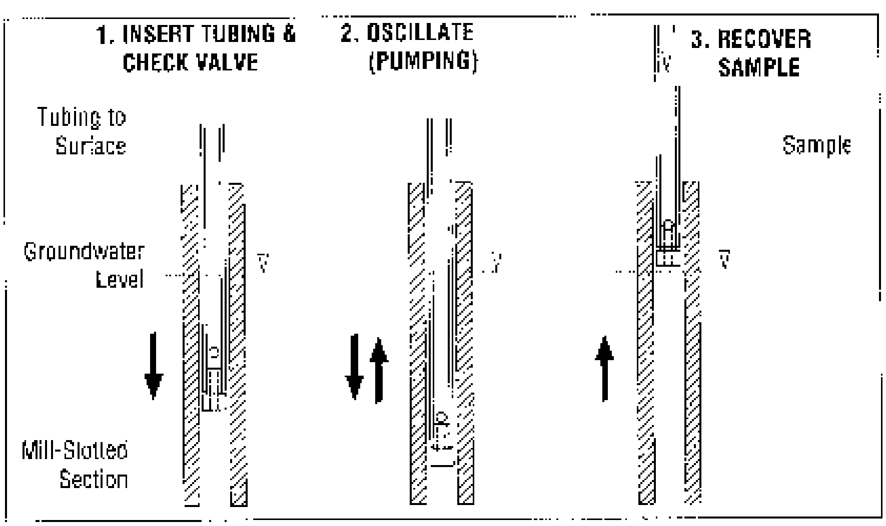


Figure 4.13. Ground Water Sampling with tubing bottom Check Valve.

b. Place a tubing check valve (P/N GW-42) at the bottom end of a roll of tubing (Fig. 4.12). This bottom check valve will fit either of the tubing types listed above.

c. Push the tubing, check valve end first, down the bore of the probe rods until it strikes the top of the screen point sampler.

d. Lift the tubing approximately 4 inches (102 mm) off the bottom (top of the screen point sampler) and oscillate the tubing up and down in 8 to 12 inch (200 to 300 mm) strokes (Figure 4.13, Steps 1 and 2). In field practice, the tubing is oscillated up and down by hand at a rate of 60 to 100 strokes per minute. This pumping can yield as much as 500 milliliters of sample per minute.

e. Air bubbles appearing in the pumped stream indicate that the pumping action is exceeding recharge from the screen point, allowing air to enter at the check valve end. For most purposes, intermixing of air with the pumped sample is undesireable. The pumping rate should be slowed and balanced with the recharge rate.

f. If water cannot be pumped to the surface, sufficient sample may be obtained by using the tubing and check valve as a bailer. Oscillate the tubing to fill it with several feet of sample and then remove the tubing from the rods (Figure 14, Step 3).

4.8 Sampling Through PRT Tubing

"PRT" (post run tubing) refers to a Geoprobe proprietary system of tubing and fittings that are used both for vapor and groundwater sampling. This tubing is inserted down the rods after the sampler has already been driven to depth and has been deployed for sampling. The top of the screen point sampler screen is equipped with a PRT fitting which serves as a recepticle for a corresponding PRT adapter fitted onto the end of the sample tubing.

In practice, the tubing with PRT adapter at the lower end is inserted down the bore of the probe rods and screwed into the recepticle on the top of the sampler screen. This procedure forms a vacuum tight sample train from the sampler screen to ground surface. Sample is normally pumped to the surface using a peristaltic pump or other vacuum source.

The advantage of this method is that the sample is only placed in contact with the stainless steel sampler screen and the sample tubing. The sample is never exposed to a free surface. The disadvantage of this method is that it is limited to maximum ground water depths of 20 to 28 feet (6 to 8.5 m) below ground surface.

The following procedures are used to obtain ground water samples using PRT fittings and tubing:

a. Either 3/8 inch (9.5 mm) O.D. Teflon (P/N TB-30T) or Polyethylene (P/N TB-25L) tubing may be used for ground water sampling. Selection of tubing material should be based on the analytes of interest and the purpose of the ground water investigation. Each of these tubings has a corresponding PRT adapter that will be required for this sampling. These adpaters are shown in the following table.

Tubing and PRT Adapters

TUBING	DESCRIPTION	PRT ADAPTER PART NUMBER
TB-30T	3/8 inch (9.5 mm) TFE	PR-30S
TB-25L	3/8 inch (9.5 mm) LDPE	PR-25S

b. Place the barbed end of the appropriate adapter into the selected tubing (Fig. 4.14).

c. Push the adapter end of the tubing down the bore of the probe rods until it comes into contact with the PRT threads at the top of the screen point sampler.

d. Rotate the tubing counter-clockwise at the surface to screw the adapter into the screen point threads (Fig. 4.15). Rotate the tubing several revolutions until the down hole adapter is completely seated and the tubing starts twisting. In this condition, the tubing will rotate backwards (clockwise) when released.

e. The tubing can now be attached to a peristaltic pump or vacuum source at the surface (Fig. 4.16).

f. After sampling is complete, tubing should be removed by pulling it up at the surface. This will pull the tubing off the barbed end of the tubing adapter and will allow the operator to examine the connection at the top end of the screen point when it is pulled from the ground.

4.9 Removal

a. Remove all sampling tubing from the bore of the probe rods.

b. Pull all probe rods from the ground using the Geoprobe machine. Care should be taken not to push down on the probe rods during removal.

c. Care should be taken to lift the screen point sampler vertically upward at the surface. Pulling the probe rods or sampler from the ground at any direction other than vertical may result in bending of the screen point sampler.

d. Dismantle the sampler at the surface and examine it for damage. Decontaminate all parts, replace all O-rings, and reassemble the sampler for the next sample.

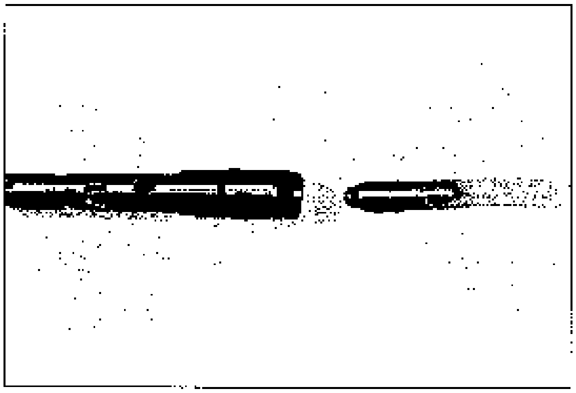


Figure 4.14. PRT-adapter connected to tubing prior to placement in the Screen Connector.

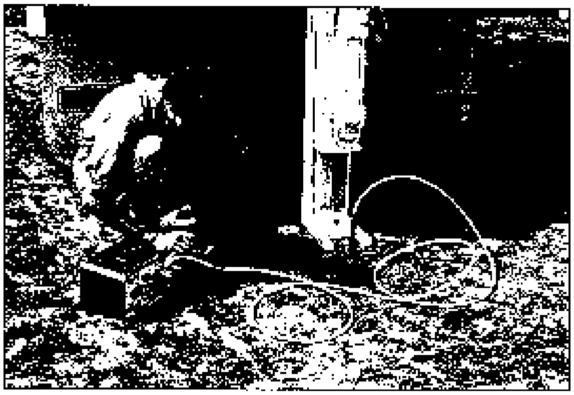


Figure 4.16. Using a Peristaltic Pump to collect a ground water sample using the Screen Point Sampler.

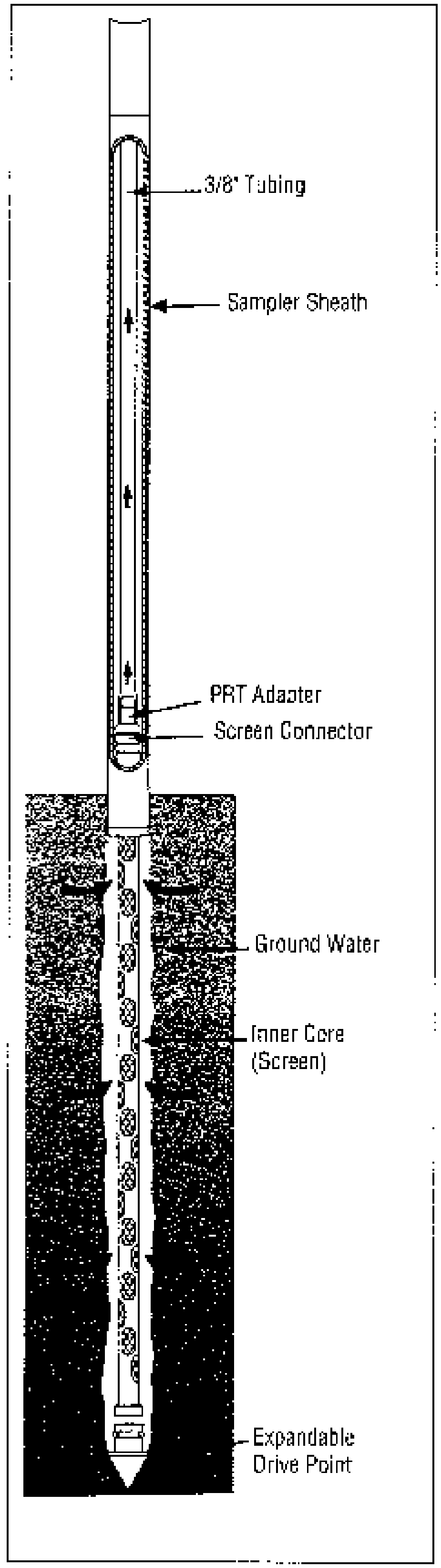


Figure 4.15. Connection of PRT tubing to the Screen Point Sampler.

5.0 REFERENCES

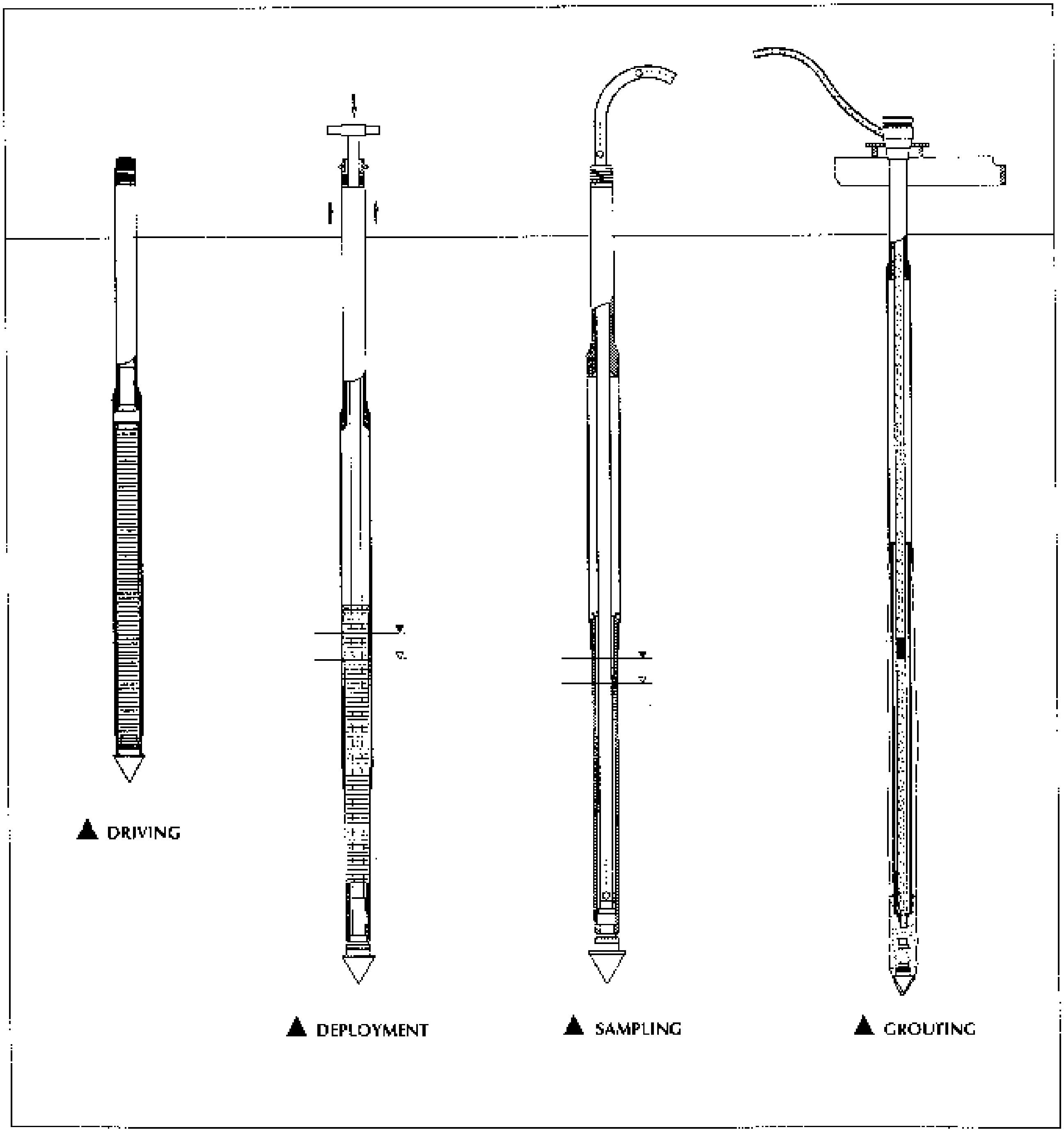
Geoprobe Systems, August 1993, "1993-94 Equipment and Tools Catalog".

Geoprobe Screen Point 15 Groundwater Sampler

Standard Operating Procedure

Technical Bulletin No. 95-1500

PREPARED: October, 1995



GEOPROBE SCREEN POINT 15 GROUNDWATER SAMPLER

Geoprobe® Systems

A DIVISION OF KEJR ENGINEERING

Geoprobe® is a Registered Trademark of Kejr Engineering, Inc., Salina, Kansas

1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel or PVC screen to depth, deploy the screen, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 15 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299-92 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe*: A vehicle-mounted, hydraulically-powered, soil probing machine that utilizes static force and percussion to advance small diameter sampling tools into the subsurface for collecting soil core, soil gas, or groundwater samples.

** Geoprobe is a registered trademark of Kejr Engineering, Inc., Salina, Kansas.*

Screen Point 15 Groundwater Sampler: The assembled Screen Point 15 Sampler (GW-1500K) is 1.5 inches (38 mm) O.D. (outside diameter) x 52 inches (1321 mm) overall length. A stainless steel or PVC screen with an exposed screen length of 41 inches (1041 mm) is utilized.

Casing Puller: An assembly which makes it possible to retract the sampler string with extension rods protruding from the top of the probe rods. The casing puller for units originally equipped with the GH-40 hammer consists of the following:

PART NAME/NUMBER	QUANTITY
Casing Pull Bracket Assembly (GW-3337)	(1)
Casing Pull Plate Assembly (GW-468)	(1)
Casing Pull Anchor Assembly (GW-3286)	(1)
Bolt, HHCS 1/2"-13 x 2" GR 5 PLTD	(2)
Lock Washer, 1/2" PLTD	(2)

These items may be obtained separately or as a Casing Pull Kit (GW-4600K).

Units originally equipped with the SK-58 hammer or retrofitted with the GH-40 hammer require a different casing puller kit. Contact Geoprobe Systems for specific information.

2.2 Discussion

In this procedure, the assembled Screen Point 15 Groundwater Sampler (**Fig. 2.1A**) is threaded onto the leading end of a Geoprobe probe rod and driven into the subsurface with a Geoprobe machine. Additional probe rods are subsequently added and driven until the desired sampling interval is reached. While the sampler is driven to depth, O-ring seals at the drive head and expendable drive point provide a watertight system. This system eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once at the desired sampling interval, extension rods are sent downhole until the leading rod contacts the bottom of the sampler screen. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods (Fig. 2.1B). As the tool string is retracted, the expendable point is released from the sampler sheath. An O-ring on the screen head maintains the seal at the top of the screen. As a result, any liquid entering the sampler during screen deployment must first pass through the screen. The tool string and sheath may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

The Screen Point 15 Sampler utilizes a screen with a standard slot size of 0.004 inches (0.1 mm) and an exposed length of 41 inches (1041 mm). Alternate slot sizes and lengths may be custom ordered. Contact Geoprobe Systems for available options. The screen is constructed such that a check valve or mini-bailer can be inserted into the screen cavity. This makes direct sampling possible from anywhere within the saturated zone. A removable plug in the lower end of the screen allows the user to grout as the sampler is extracted for further use.

Groundwater samples can be obtained in a number of ways. The most common method utilizes polyethylene or Teflon® tubing and a Tubing Bottom Check Valve (GW-42). The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is pumped through the tubing and to the ground surface by oscillating the tubing up and down. Another means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). A final technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW-41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

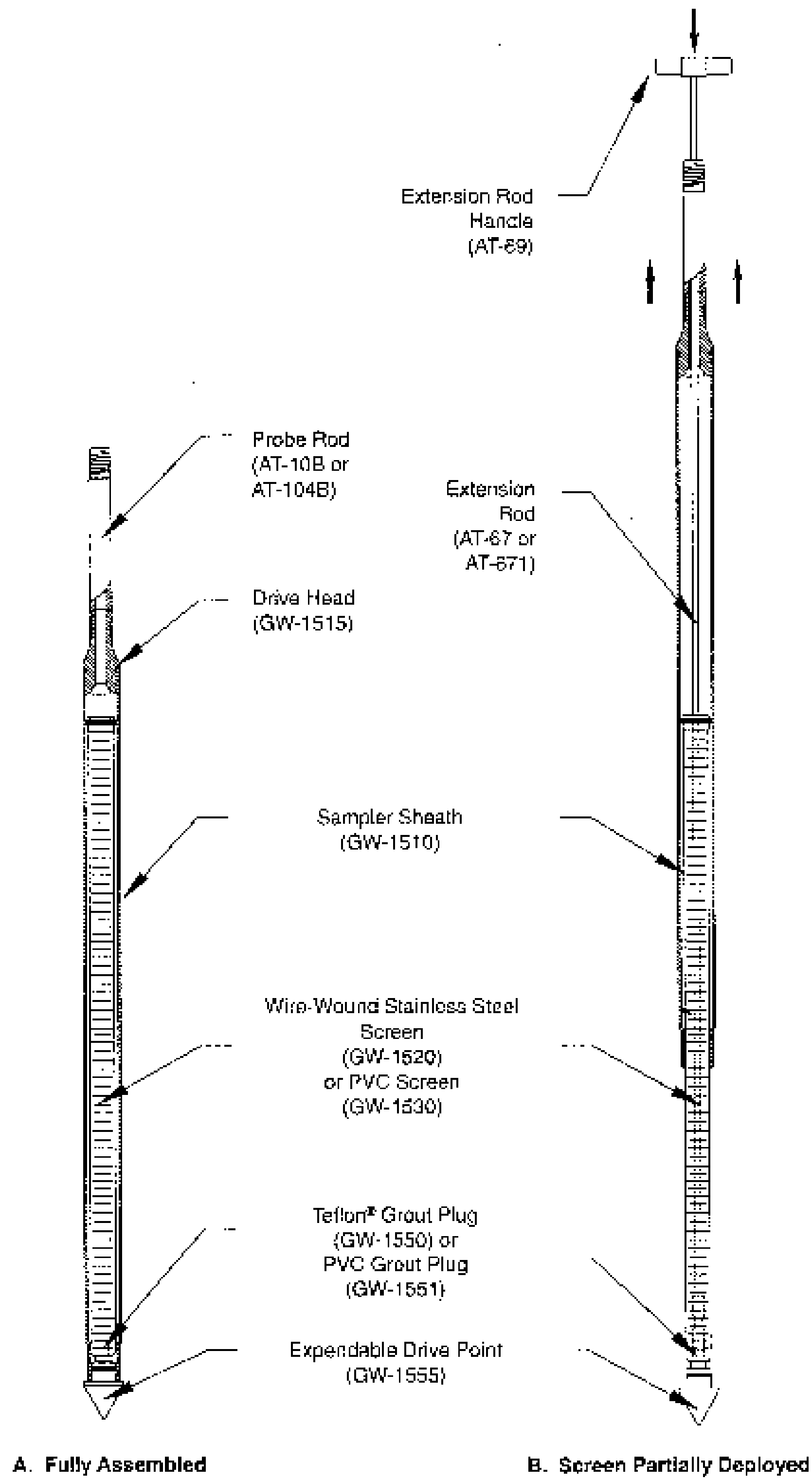


FIGURE 2.1
Screen Point 15 Groundwater Sampler

3.0 REQUIRED EQUIPMENT

The following equipment is required to successfully recover representative groundwater samples with the Geoprobe Screen Point 15 Groundwater Sampler and probing system. See Figure 3.1 for Screen Point 15 parts identification.

Screen Point 15 Groundwater Sampler Parts	Quantity	Part Number
O-ring Service Kit (contains 100 of each O-ring required)	-1-	GW-1504K*
Sampler Sheath	-1-	GW-1510*
Drive Head	-1-	GW-1515*
Wire-Wound Stainless Steel Screen, 4-Slot	-1-	GW-1520*
PVC Screen (optional)	-1-	GW-1530
Screen Push Adapter	-1-	GW-1535*
Grout Plug Push Adapter	-1-	GW-1540*
Grout Plugs, Teflon® (Pkg. of 25 plugs)	-1-	GW-1550K
Grout Plugs, PVC (Pkg. of 25 plugs)	-1-	GW-1551K*
Expendable Drive Points (Pkg. of 25 points)	-1-	GW-1555K*
Grout Nozzle	-1-	GW-1545
Casing Puller Kit (for GH-40 hammer)	-1-	GW-4600K

*Denotes part is included in Screen Point 15 Groundwater Sampler Kit (GW-1500K).

Geoprobe Tools	Quantity	Part Number
Probe Rod (36")**	Variable	AT-10B
Probe Rod (48")**	Variable	AT-104B
Drive Cap	-1-	AT-11B
Pull Cap	-1-	AT-12B
Split Pull Cap (Optional)	-1-	AT-113
Extension Rod (36")**	Variable	AT-67
Extension Rod (48")**	Variable	AT-671
Extension Rod Coupler	Variable	AT-68
Extension Rod Handle	-1-	AT-69
Extension Rod Jig	-1-	AT-690
Quick Link Extension Rod Connectors (Optional)	Variable	AT-694K

**Either 36-inch or 48-inch probe rods and extension rods may be used. Both lengths are not required.

Additional Tools	Quantity
Locking Pliers	-1-
Pipe Wrenches	-2-

Note: Replacement parts may be obtained in various kits. Contact Geoprobe Systems for specific packages.

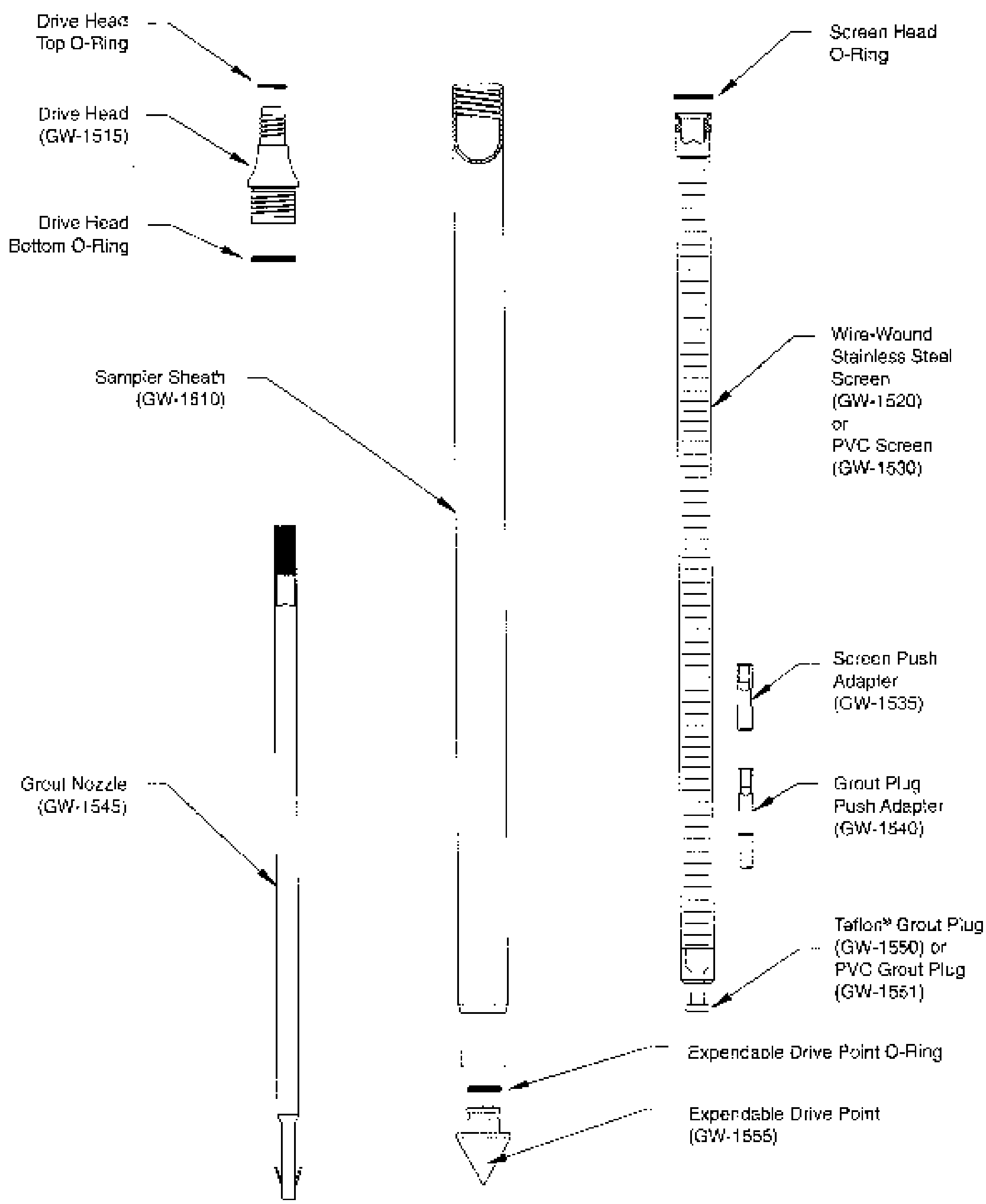


FIGURE 3.1
Screen Point 15 Groundwater Sampler Parts

4.0 OPERATION

4.1 Basic Operation

The Screen Point 15 Groundwater Sampler utilizes a stainless steel or PVC screen which is encased in an alloy steel sampler sheath. An expendable drive point is placed in the lower end of the sheath while a drive head is attached to the top. O-rings on the drive head and expendable point provide a watertight sheath which keeps contaminants out of the system as the sampler is driven to depth. Once the desired sampling interval is reached, extension rods equipped with a screen push adapter are inserted down the inside diameter of the probe rod string. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods. At this point the system is ready for groundwater sampling. When sampling is complete, a removable plug in the bottom of the screen allows for grouting below the sampler as the tool string is retrieved.

4.2 Decontamination

In order to collect representative groundwater samples, all Screen Point 15 parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff, long-bristle brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

4.3 Sampler Assembly (Fig. 4.1)

1. Install an O-ring on an expendable drive point (GW-1555). Firmly seat the expendable point in the necked end of a sampler sheath (GW-1510).

2. Place a grout plug (Teflon® GW-1550 or PVC GW-1551) in the lower end of a wire-wound stainless steel (GW-1520) or PVC screen (GW-1530). When using the stainless steel screen, install an O-ring in the groove on the upper end of the screen. Slide the screen inside of the sampler sheath with the grout plug toward the bottom of the sampler. Ensure that the expendable point was not displaced by the screen.

3. Install a bottom O-ring on a drive head (GW-1515). Thread the drive head onto the sampler sheath. Attach a drive cap (AT-11B) to the top of the drive head. The drive head and cap must only be hand tight. Tools are not required as long as the attachments completely thread together.

4. Sampler assembly is complete.

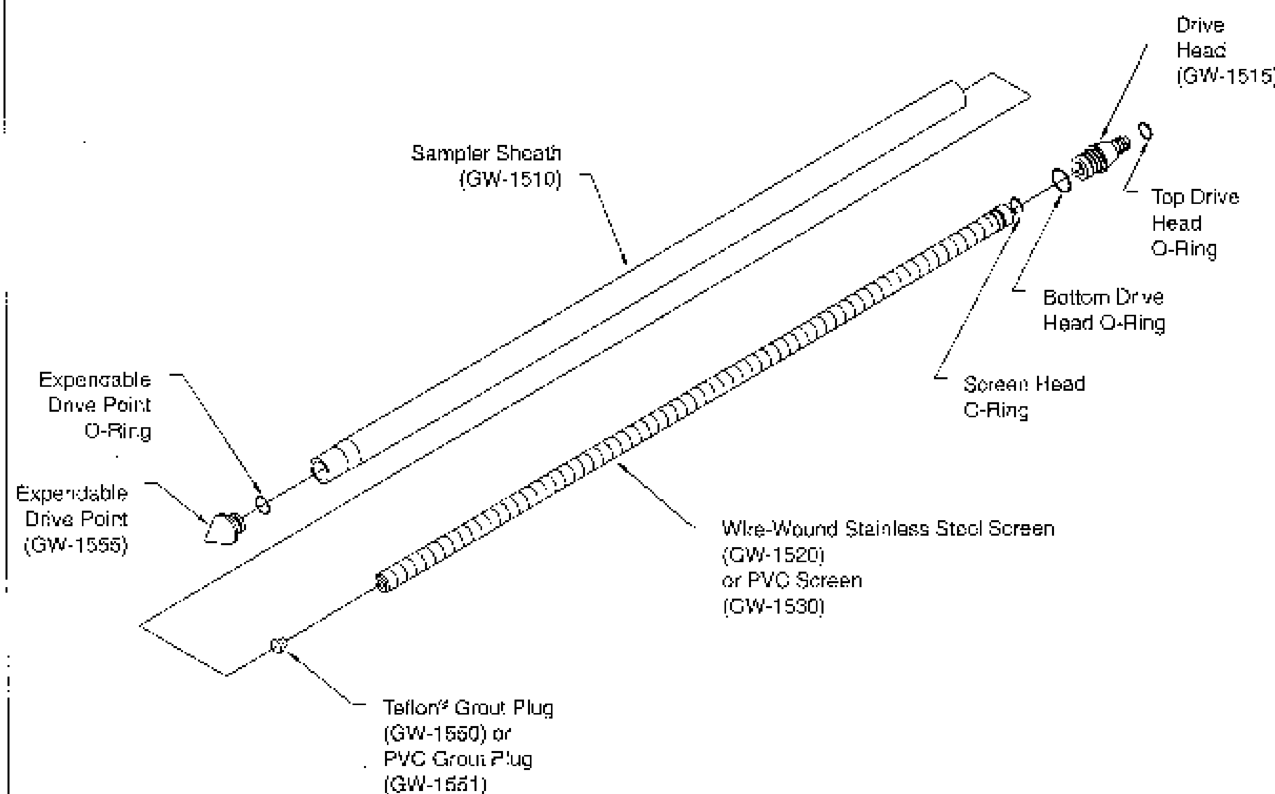


FIGURE 4.1
Screen Point 15 Groundwater Sampler Assembly

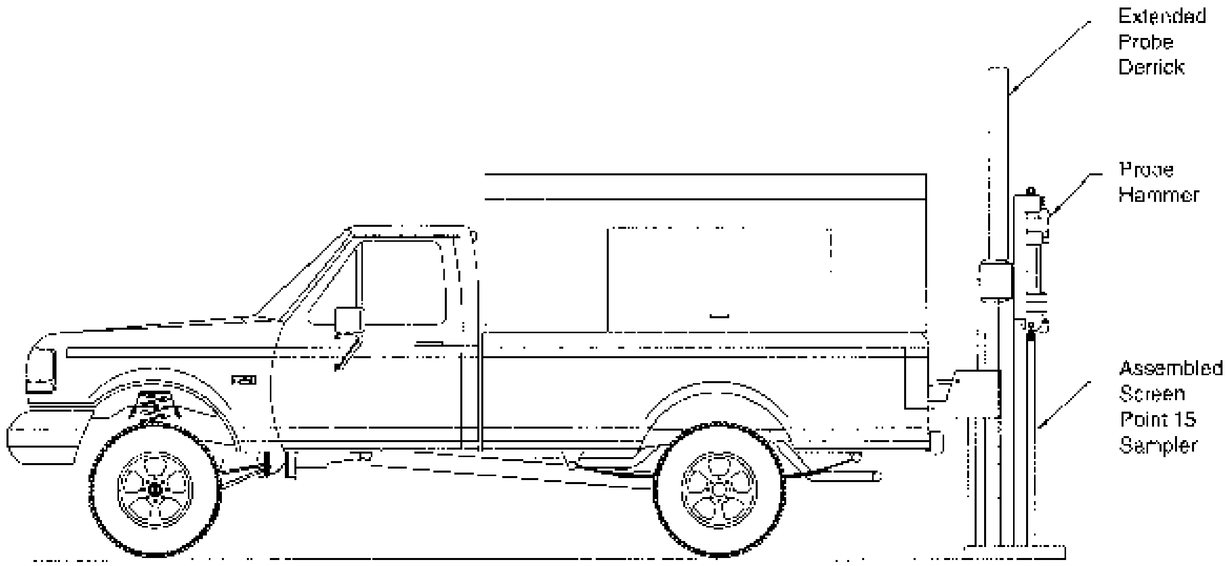


FIGURE 4.2
Screen Point 15 Groundwater Sampler in Driving Position

4.4 Driving the Screen Point 15 Sampler

To provide adequate room for screen deployment with the casing puller assembly, the probe derrick should be extended a little over halfway out of the carrier vehicle before driving the Screen Point 15 Sampler

1. Begin by placing the assembled sampler (Fig. 2.1) in the driving position beneath the hammer anvil on the extended probe derrick (Fig. 4.2).

2. Drive the sampler with throttle control at slow speed for the first 1 or 2 feet to ensure that the sampler is driving straight. Switch the throttle control to fast speed for the remainder of the probe stroke.

3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the drive head. Distilled water may be used to lubricate the O-ring if needed. Add a 36- or 48-inch (914 or 1219 mm) probe rod and reattach the drive cap to the rod string. Drive the sampler the entire length of the new rod with the throttle control at fast speed.

4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.

5. Remove the drive cap and retract the probe derrick away from the tool string.

4.5 Screen Deployment

1. Thread the screen push adapter (GW-1535, Fig. 4.3) on an extension rod (AT-67 or AT-671). Attach a coupler (AT-68) to the other end of the extension rod. Lower the extension rod inside of the probe rod taking care not to drop it down the tool string. An extension rod jig (Fig. 4.3) may be used to hold the rods.

2. Add extensions until the adapter contacts the bottom of the screen. To speed up this step, extension rod Quick Links (AT-694K, Fig. 4.3) are recommended.

3. Install the casing pull bracket (GW-3337) on the probe hammer (Fig. 4.4).

4. Reposition probe derrick and hammer assembly such that casing pull bracket is below top of probe rod.

5. Place the casing pull plate (GW-468) over the probe rod and install an open-bore pull cap (AT-12B) as shown in Figures 4.5A and B.

6. Ensure that at least 48 inches (1219 mm) of extension rod protrudes from the probe rod. Thread an extension rod handle (AT-69, Fig. 4.3) on the top extension.

7. Retract probe rods and sampler sheath while physically holding the screen in place with the extension rods (Fig. 4.5B). A slight knock with the extension rod string will help to dislodge the expendable point and start the screen moving inside the sheath. Raise the hammer and pull bracket assembly about 44 inches (1118 cm). At this point the screen head will contact the necked portion of the sampler sheath (Fig. 4.5C.) and the extension rods will rise with the probe rods. The screen is now deployed. Use care when deploying a PVC screen so as not to break the screen when it contacts the bottom of the sampler sheath.

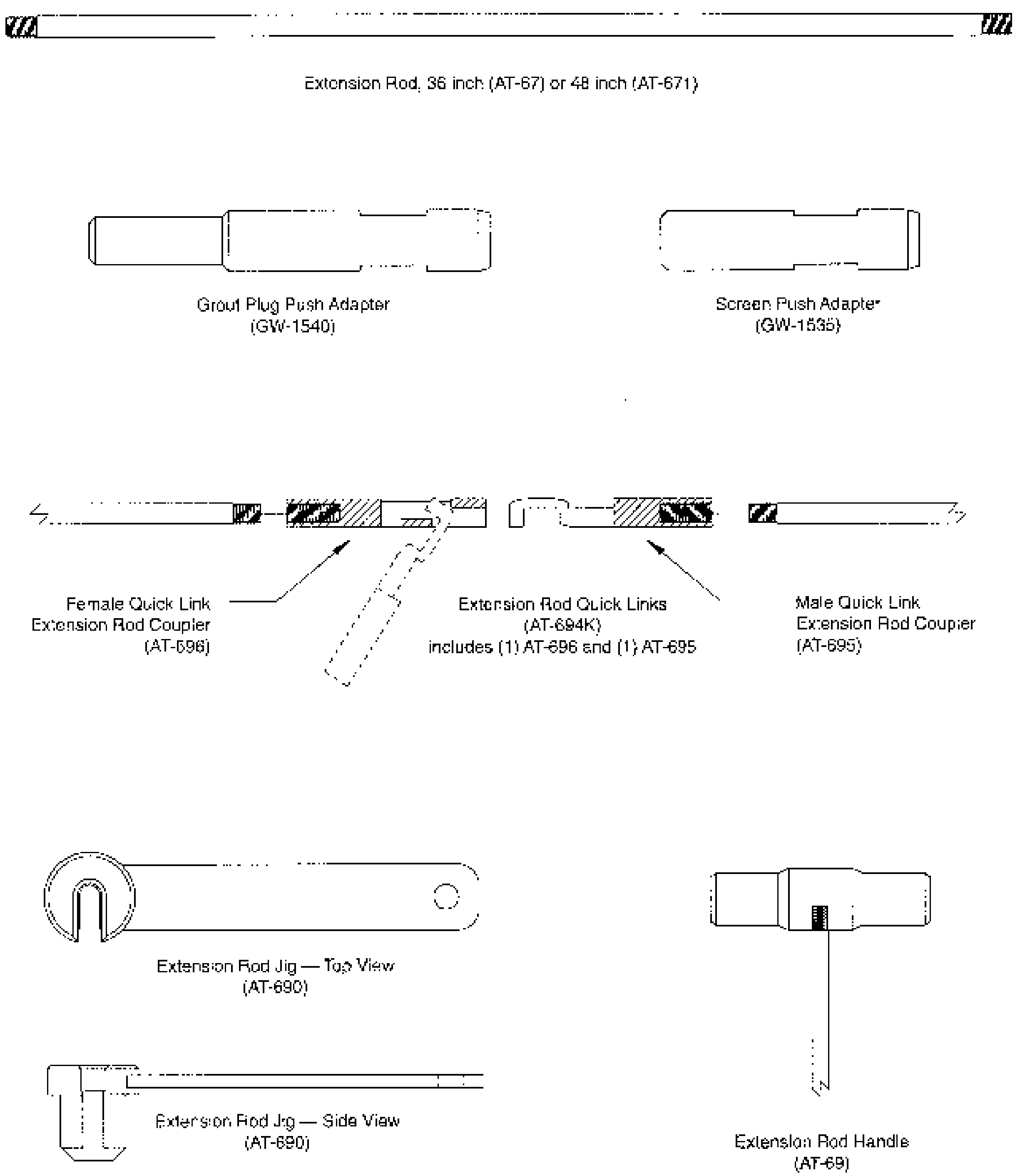
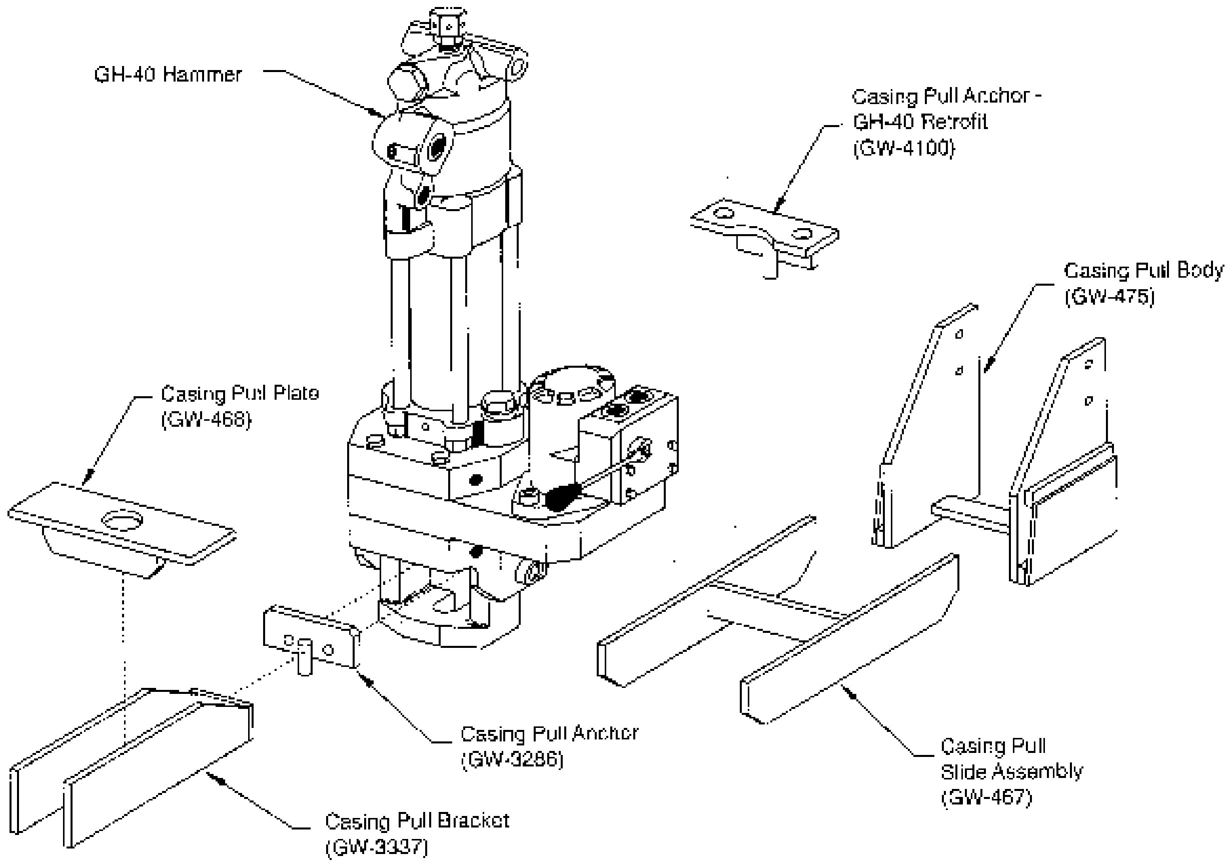


FIGURE 4.3
Geoprobe Extension Rods and Accessories



NOTES:
1) For GH-40 Hammer Retrofit Applications, Substitute GW-4100 for GW-3286.
2) For SK58 Hammer Applications, Substitute GW-467 for GW-3337, and GW-475 for GW-3286.

FIGURE 4.4
Casing Pull Assembly for Units Originally Equipped With The GH-40 Hammer

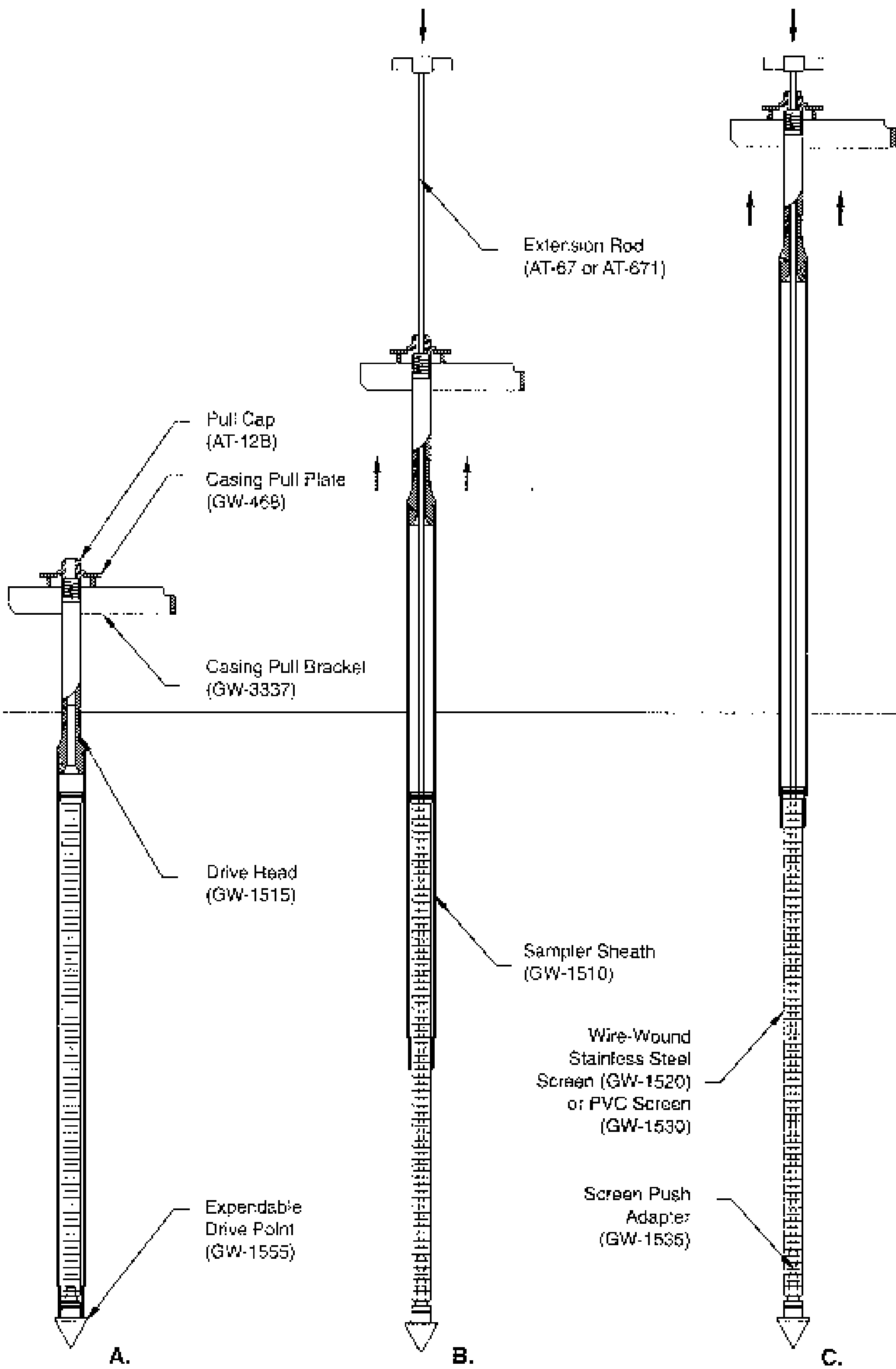


FIGURE 4.5
Screen Deployment

8. Lower the hammer assembly and retract the probe derrick. Remove the top extension rod and handle, pull cap, casing pull plate, and top probe rod. Finally, extract all extension rods.

9. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing / bottom check valve assembly, or other acceptable small diameter sampling device.

10. When inserting the tubing down the rod string to collect a sample, ensure that the tubing enters the screen interval. The tubing will sometimes catch on the edge of the funnel opening of the screen head. An up-and-down and turning motion with the tubing helps to move it past the lip and into the screen.

4.6 Abandonment Grouting

The Screen Point 15 Sampler can meet ASTM D 5299-92 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of the screen. Grout is then pumped into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Position the casing pull bracket and pull plate over the tool string and place a split pull cap (AT-113) on the top probe rod. The sampler string can be pulled with the hammer latch while grouting. It is easier to manipulate the grout tube and probe rods, however, when the casing puller is utilized. A split pull cap is necessary for abandonment grouting as it makes it possible to pull probe rods without disconnecting the grout tube from the pump.

   Raise the tool string approximately 4 to 6 inches (102 to 152 cm) to allow removal of the grout plug. Remove the pull cap.

2. Thread the grout plug push adapter (GW-1540, Fig. 4.3) onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extensions until the adapter contacts the grout plug at the bottom of the screen. When the extension rods are slightly raised and lowered, a relatively soft rebound should be felt as the adapter contacts the grout plug. This is especially true when using a PVC screen.

3. Apply pressure to the extension rods and push the grout plug out of the screen. If working with a stainless steel screen, it may be necessary to raise and quickly lower the extension rods (much like a hammering action) to jar the plug free. When the plug is successfully removed from the stainless steel screen, a metal-on-metal sensation will be noted as the extension rods are quickly raised and lowered.

   Note: Do not attempt to hammer on the grout plug if utilizing a PVC screen as the screen may break. A steady downward force should dislodge the plug.

   When the grout plug is pushed from the screen, remove all extension rods.

4. A grout nozzle (GW-1545) is now connected to polyethylene tubing and inserted into the probe rods and down through the bottom of the screen (Fig. 4.6). Water flow should be maintained through the grout tubing and nozzle during deployment to prevent plugging the tube with sediment. Resistance will be felt as the grout nozzle passes through the drive head. Note this point as the nozzle tip should exit the end of the screen in approximately another 92 inches (2337 mm). Mark the tubing as desired.

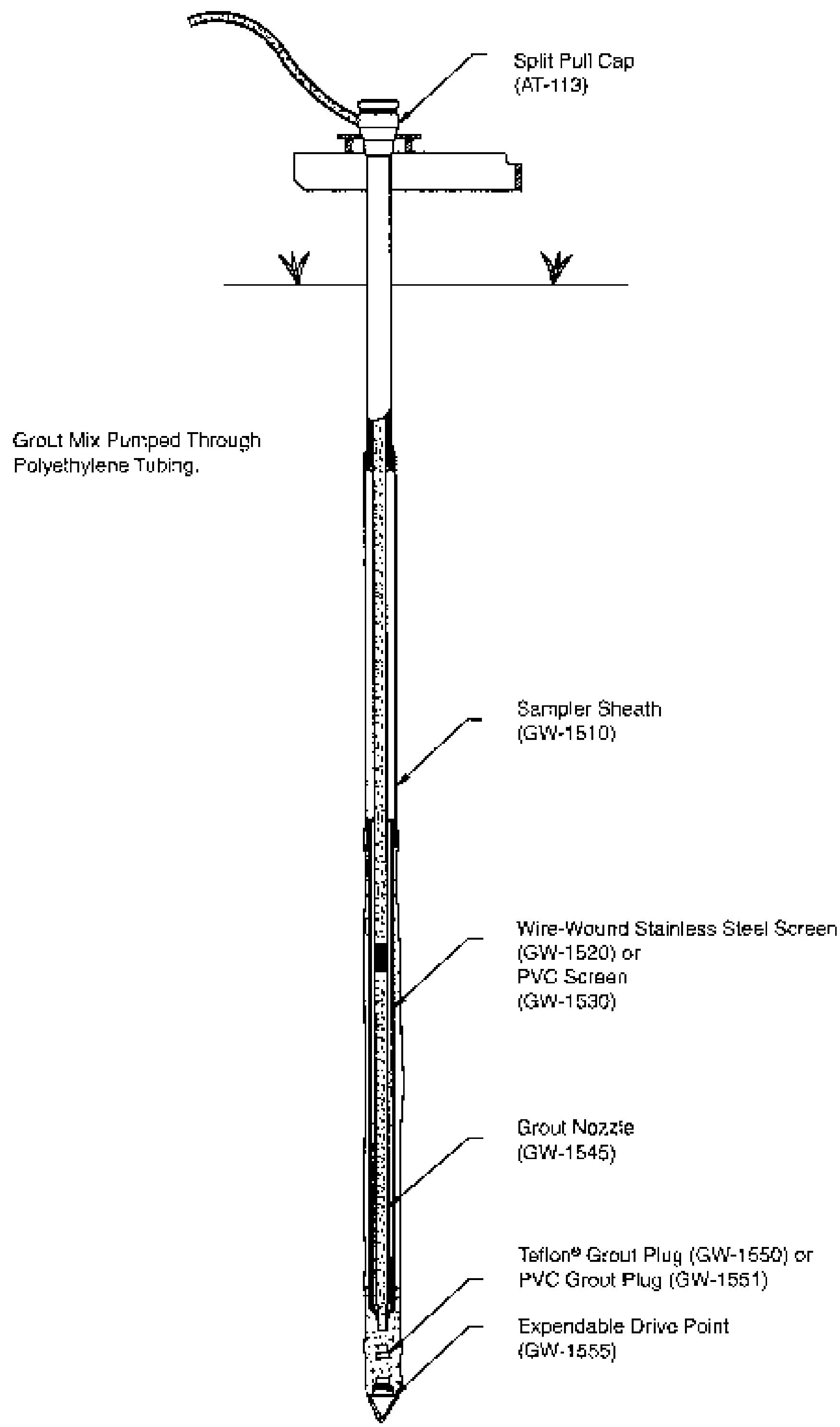


FIGURE 4.6

Grouting Through The Screen Point 15 Groundwater Sampler

Once fully deployed, the two spring-like tongues at the end of the grout nozzle (Fig. 4.6) will expand and prevent it from coming up out of the hole while pumping grout. Gently pull up on the polyethylene tubing to ensure that the nozzle has locked into place.

Note: All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 30 percent length is generally enough.

5. Attach a split pull cap to the top probe rod. Position the polyethylene tubing in the pull cap slot taking care not to pinch or bind the tubing. Operate the grout pump while pulling the first rod. Remove the split pull cap and unscrew the probe rod. Slide the rod over the tubing and place it on the ground near the end of the tubing to leave room for the remaining probe rods.

6. Repeat Step 5 until the sampler is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.

7. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.7 Retrieving the Screen Point 15 Sampler

If grouting is not required, the Screen Point 15 sampler can be retrieved by pulling the probe rods as with most other Geoprobe sampling applications.

1. Position the probe derrick and hammer assembly over the tool string. Thread a pull cap onto the top probe rod. Once again, a split pull cap may be used to save time.

2. Lower the hammer latch over the pull cap and retract the tool string one probe rod length.

3. Remove the pull cap and top probe rod and repeat Step 2 until the sampler sheath is at the ground surface.

4. Physically pull the sampler sheath and screen out of the ground taking care not to bend the screen on the way out. The Screen Point 15 Groundwater Sampler is now retrieved and ready to decontaminate for further use.

5.0 REFERENCES

American Society for Testing and Materials (ASTM) 1993. Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities: D 5299-92.

Geoprobe Systems, 1995, "1995-96 Tools and Equipment Catalog".

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems.

APPENDIX B

Oxygen and Hydrogen Iostope Analysis of Water

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STABLE ISOTOPE RATIO ANALYSIS (SIRA) LABORATORY

OXYGEN ISOTOPE ANALYSIS OF WATER

PREPARATION
For oxygen SIRA, water samples are prepared using the CO_2/water equilibration method of Epstein and Mayeda (see Geochimica et Cosmochimica Acta 4, 213-224, 1953). In this technique, a known volume of water sample is combined in a sealed tube with a known volume of CO_2 gas and allowed to equilibrate for at least 24 hours at 25 °C. At Geochron, we normally combine 2 ml of water sample (if available) with 5 ccSTP of Tank CO_2 gas in a standard 7 ml vacutainer. (Smaller samples (eg. mineral water of hydration) can be accommodated using a Micro-CO_2/water equilibration technique developed here at Geochron.) After equilibration, the CO_2 gas is cryogenically purified by passing it through a dry ice/alcohol trap (-78.5 °C) to remove H_2O, and then trapped in two liquid nitrogen traps (-196 °C). The frozen CO_2 is pumped-on to a vacuum of at least 100 mtorr to remove any non-condensible gases, and then cryogenically transferred to a sample flask and sealed to await analysis on the mass spectrometer.

ANALYSIS
The oxygen-18/oxygen-16 ratio of the equilibrated CO_2 gas is determined on a VG Micromass gas source stable isotope ratio mass spectrometer (Model 903). In practice, the actual ratio is not measured directly, but rather is determined by comparison of the sample gas with a reference CO_2 gas. This method avoids many possible sources of instrumental error since both the reference and sample gases are affected and the errors are cross-cancelling in the calculation of the results.

Three measurements each of the reference and sample gases are made allowing four $^{18}O/^{16}O$ ratios to be calculated for statistical comparison. If the instrumental precision on the measured oxygen ratios exceeds 0.08 ‰, the analysis is rejected and the gas is rerun.

The oxygen isotopic difference between the Tank CO_2 and the equilibrated CO_2 is directly related to the oxygen isotope composition of the sample water. The latter can be calculated by mass balance considerations knowing the the volumes of sample water and Tank CO_2 involved, the $^{18}O/^{16}O$ ratio of the Tank CO_2, and the CO_2 - water oxygen isotope fractionation factor at 25 °C.

The final SIRA results are reported in terms of the relative difference (delta value denoted by the symbol δ) in parts per thousand (termed per mil, and denoted by the symbol ‰) of the $^{18}O/^{16}O$ ratio of the sample relative to that of the internationally

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STABLE ISOTOPE RATIO ANALYSIS (SIRA) LABORATORY

OXYGEN ISOTOPE ANALYSIS OF WATER
(cont.)

ANALYSIS (cont.)
accepted standard Standard Mean Ocean Water (SMOW). The method precision for oxygen SIRA on water is about +/- 0.2 °/oo.

Duplicate preparations and analyses are routinely done on about 1 in 10 samples, or when an anomalous result is suspected. If the results of duplicate analyses are not within 0.3 °/oo of each other, the sample is prepared and analyzed again.

REFERENCE GAS/INSTRUMENT CALIBRATION
Two aliquots (Ref I and Ref II) of reference CO_2 are produced periodically by reaction of Geochron's in-house carbonate (marble) standard (COR-0101) with 100% orthophosphoric acid in an evacuated reaction vessel at 50 °C. After both references gases have been analyzed with respect to the previous reference gas (if available), they are analyzed against each other so that their relative compositions are well characterized. One of the reference gases (usually Ref I) is then put into use, and its composition is monitored by periodically analyzing the other reference, providing an internal check on its composition. If the difference in composition between Ref I and Ref II changes by +/- 0.2 °/oo, two new reference gases are produced.

The calibration of the CO_2 reference gases is monitored by periodically analyzing various international reference materials, including SMOW ($\delta^{18}O$ = 0.0 °/oo), and Standard Light Antarctic Precipitation (SLAP - $\delta^{18}O$ = -55.5 °/oo). However, in order to conserve these standard materials, an in-house reference water (OR-76664) is maintained which has a $\delta^{18}O$ composition of -6.9 °/oo. If the results of these analyses are consistently > 0.2 or < 0.2 °/oo off from the accepted values, two new reference gases are produced.

Zero enrichment measurements are accomplished on a weekly basis. Three or more measurements are taken and averaged. If the average exceeds +/- 0.05 °/oo, a zero enrichment is input into the program.

Updated 2 OCT 1996

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STABLE ISOTOPE RATIO ANALYSIS (SIRA) LABORATORY

HYDROGEN ISOTOPE ANALYSIS OF WATER
Uranium Reduction

PREPARATION

For hydrogen SIRA, hydrogen gas is generated from each water sample by the uranium reduction method. The water (about three microliters) is introduced into the preparation line, doubly distilled and passed through metallic uranium heated to 800 °C. At this temperature, the water reacts with the uranium producing H_2 gas. As the gas is produced, it is reacted to uranium hydride (UH_3) in an absorption reservoir of metallic uranium at 80 °C. This ensures that the reduction of water to H_2 goes to completion. The UH_3 is then quantitatively decomposed back to H_2 gas at 800 °C and the H_2 is introduced directly into the mass spectrometer for analysis.

The memory effect caused by adsorption of the H_2 onto the uranium metal has a magnitude of about 3% for samples of natural compositions. For differences of < 50 °/oo from one sample to the next, the memory effect is less than the analytical uncertainty of the method which is +/- 2 °/oo. If a difference of > 50 °/oo is found between two samples, additional aliquots are prepared until equilibrium is obtained.

ANALYSIS

The Deuterium/Hydrogen (D/H) ratio is determined using a VG Micromass gas source stable isotope ratio mass spectrometer (Model 602D). In practice, the actual ratio is not measured directly, but rather is determined by comparison of the sample H_2 gas with a reference H_2 gas. This method avoids many possible sources of instrumental error since both the reference and sample gases are affected and the errors are cross-cancelling in the calculation of the results.

Four measurements each of the reference and sample gases are made allowing six D/H ratios to be calculated for statistical comparison. If the instrumental precision on the measured hydrogen ratios exceeds 1 °/oo, the analysis is rejected and the gas is rerun.

The raw data are corrected for the production of H_3^+ in the analyzer which is checked daily.

2 OCT 1996

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STABLE ISOTOPE RATIO ANALYSIS (SIRA) LABORATORY

HYDROGEN ISOTOPE ANALYSIS OF WATER
Uranium Reduction
(cont.)

ANALYSIS (cont.)

The final SIRA results are reported in terms of the relative difference (delta value denoted by the symbol δ) in parts per thousand (termed per mil, and denoted by the symbol $^o/oo$) of the D/H ratio of the sample relative to that of the internationally accepted standard Standard Mean Ocean Water (SMOW). The method precision for hydrogen SIRA on water is about +/- 2 $^o/oo$.

Duplicate preparations and analyses are routinely done on about 1 in 10 samples, or when an anomalous result is suspected. If the results of duplicate analyses are not within 3 $^o/oo$ of each other, the sample is prepared and analyzed again.

REFERENCE GAS/INSTRUMENT CALIBRATION

The reference gas is produced from an aliquot of local tap water by the uranium reduction method.

The reference H_2 gas is calibrated with respect to Standard Mean Ocean Water (SMOW - $\delta D = 0$ $^o/oo$) and Standard Light Antarctic Precipitation (SLAP - $\delta D = -428$ $^o/oo$) using the method recommended by the International Atomic Energy Agency (see Nature 271, 534-536, 1978). Replicate analyses of each standard are run against the reference gas and the SMOW/SLAP scale is determined.

The calibration of the reference gas is checked periodically by preparing and analyzing additional aliquots of SMOW and SLAP, as well as other reference materials including Greenland Ice Sheet Precipitation (GISP - $\delta D = -190$ $^o/oo$).

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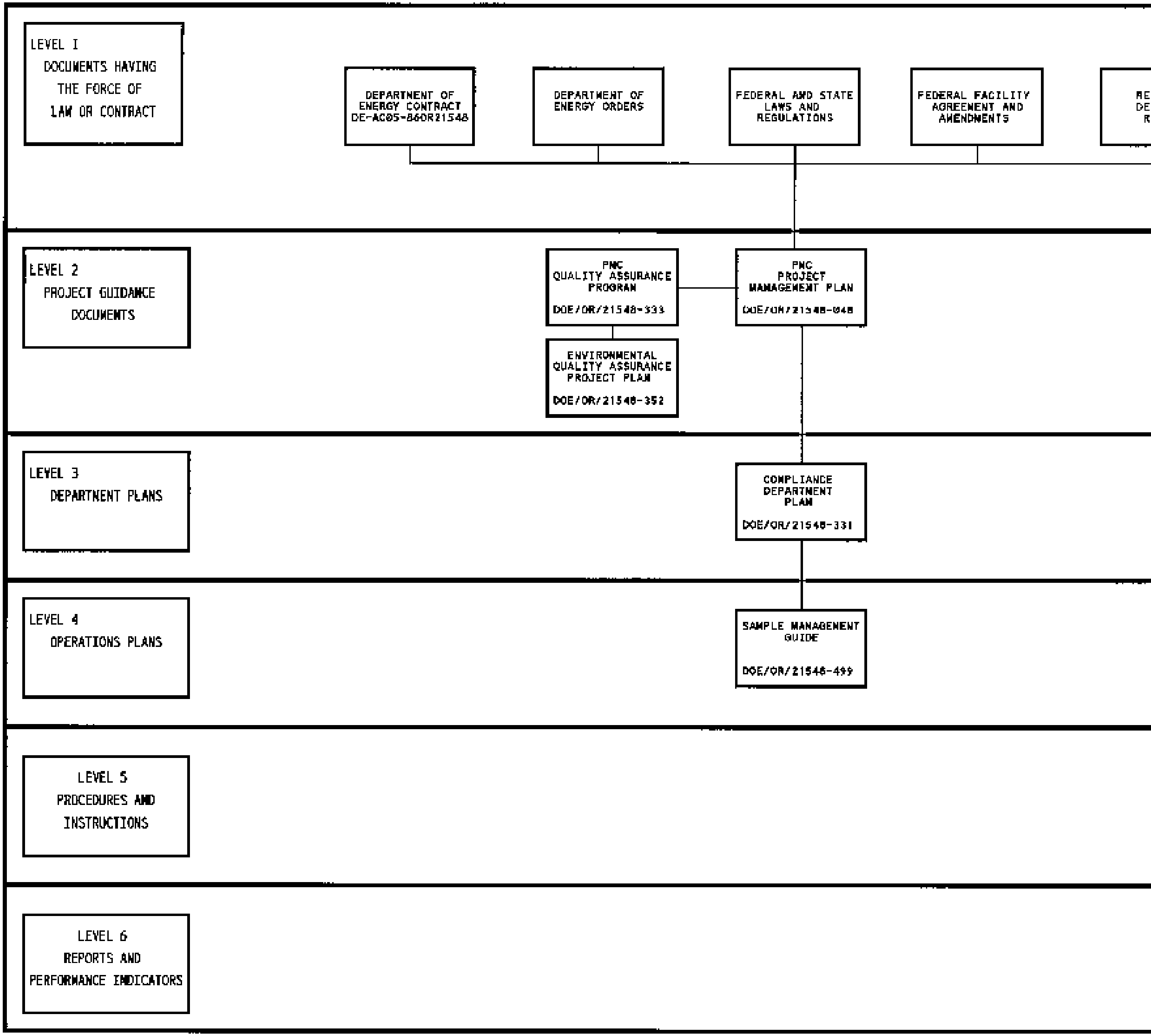
APPENDIX C
Document Hierarchy



SAMPLING PLAN FOR THE FEASIBILITY STUDY FOR THE QUARRY RESIDUALS OPERABLE UNIT AT THE WELDON SPRING SITE, WELDON SPRING, MO

DOCUMENT NUMBER	DATE
DOE/OR/21548-699	6/25/97